FOREST MANAGEMENT STRATEGIES FOR THE LOWER SOUTH COAST REGION OF NEW SOUTH WALES

Thesis submitted by

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DECLARATION

Except where indicated otherwise, I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any other university or other institute of tertiary education. Information derived from the published and unpublished work of others has been acknowledged in the text and a list of references given. Certain sections of the investigation were carried out jointly with other people, namely, the investigation of the social discount rate and the social opportunity cost of capital, with Dr. I.S. Ferguson, and development of a matrix generator for application to linear programming problems in forestry, with Mr. J.A. Miles and Dr. I.S. Ferguson.

J.J. Reilly

J.J. Reilly,
30 September, 1978

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ABSTRACT

The aim of the study was to develop a suitable economic model of wood production for application to land-use planning situations particularly in regions where forestry is already, or could be, prominently featured and where large areas of marginal farmland exist. The Lower South Coast was adopted as the Region on which to base the model.

The investigation was divided into two parts; Part I, a comparative analysis of farming and forestry in the Region; and Part II, development of a linear programming model for the identification of the optimal set of strategies for wood production from the Region.

The analyses were based on the principles of cost-benefit analysis and the criterion used was the present value of net social benefits. The social rate of discount was estimated to lie somewhere between 4 and 6 percent with 5 percent the most likely value. Shadow prices were also computed for the various sources of capital. They were estimated to be \$3.62, \$2.73 and \$2.19 per dollar for loan funds at 4, 5 and 6 percent discount rate respectively and \$1 per dollar for other sources of capital.

The comparative analysis in Part I showed that about 130,000 hectares of farmland were available for softwood planting of which some 70,000 hectares were considered to be marginal. Forestry in the form of radiata pine plantations was found to be more economic than farming irrespective of the assumptions relating to prices, costs and yields and regardless of the discount rate used. The production of sawlogs rather than pulpwood represented the most economic strategy for radiata pine plantations.

In Part II, two models were developed, one (designated model R1) based essentially on existing plans for wood production from the Region including softwood planting on Crown lands in the Bombala Sub-District and the other (designated model R2) which proposed shifting planting entirely to the farmland. The two models were treated as mutually exclusive proposals. It was established that the native forests were more than capable of meeting industry commitments over the 50-year planning horizon adopted and there appeared to be grounds for increasing these commitments. In general, strategies of lowest intensity were only required in these forests.

The present value of net social benefits for model R1 was $9.7 million greater than that for model R2, suggesting that the proposed programme of planting on Crown lands in the Bombala Sub-District is to be preferred to the conversion of marginal farmland. This difference was magnified when the annual planting rate on the farmland in model R2 was reduced to a level comparabl with that proposed for the Bombala plantations.

The principal bone of contention in accepting these results relates to the opportunity cost of the native forests to be cleared for planting in model R1, since it did not incorporate higher net social benefits resulting from recreational, aesthetic preservation and/or scientific uses. Therefore, there is a possibility that the present value for model R1 is overstated and that for model R2 is understated. However, the difference in the present values between the two models seems likely to outweigh any revisions of opportunity cost for the native forests to be cleared for planting in model R1.

The two models can be used to evaluate other policy issues - in particular, some reduction in the scale of the two planting programmes proposed and integration of them.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

The softwood planting programme in Australia has become the centre of public debate in recent years, particularly where indigenous forests are being cleared for this purpose. The need for such clearing when there are areas of marginal farmlands available that might be used to greater social benefit has been vigorously disputed by opponents of the programme. Support for their viewpoint has also been given in reports of various public inquiries.

The Committee of Inquiry into the National Estate (1974), for example, suggested that there was no justification at all for this kind of operation and that every effort should be made to restrict needed pine plantings to degraded farm or pastoral land, or land of low productive potential for agriculture already cleared of timber. The House of Representatives Standing Committee on Environment and Conservation (1975) maintained a similar stance in concluding that insufficient use was made of marginal farmland during the 10-year period of operation of the Softwood Forestry Agreements Acts 1967 and 1972 and recommended that any finance lent to the States for this purpose in the future should be applied increasingly to the planting of such land.

In many cases forestry may provide a more economic alternative for marginal farmland, and such a change in land use may also aid rural adjustment programmes. However in order to provide a compact block of sufficient area and suitable location, some viable farms may have to be purchased as well (Harris et al., 1974).

Although most State forest services have purchased areas of private land for plantation development, acquisition has been limited by available finance and because the prices of agricultural land on the open market are often inflated in many areas by (1) the capitalized value of the subsidies granted to agriculture, especially dairying, and (2) by land speculation. This makes it difficult for the forest services to compete for this land, even where farming is obviously marginal, and it frequently makes the purchase of viable farms impossible to justify at current prices.

If the potential role of plantation forestry in aiding rural reconstruction is to be realised, changes in rural adjustment policy are needed to enable the State forest services to purchase land in marginal farming areas without at least incurring the financial burden of the capitalized subsidies. Before these measures can be argued, however, it is necessary to show that society would benefit from such changes in land-use in terms of greater economic efficiency not only of the land in question but also of the existing indigenous forests.

The aim of this study was therefore to develop a suitable economic model of wood production for application to land-use planning situations particularly in regions where forestry is already, or could be, prominently featured and where large areas of marginal farmland exist.

The Lower South Coast was adopted as the Region on which to base the model. The commencement of a woodchip export project in recent years, the decline in income from dairy farming and, more recently, beef grazing, the conversion of indigenous forest to exotic pine plantations, together with increasing demands on the forest areas for recreation and wilderness - all combine to provide the ingredients for an extremely complex land-use situation.

THE LOWER SOUTH COAST REGION

The Lower South Coast Region as defined here is located in the south-east corner of New South Wales (Figure 1.1) extending over 1,150,000 ha of which about 200,000 ha are farmed. Slightly more than 80 percent

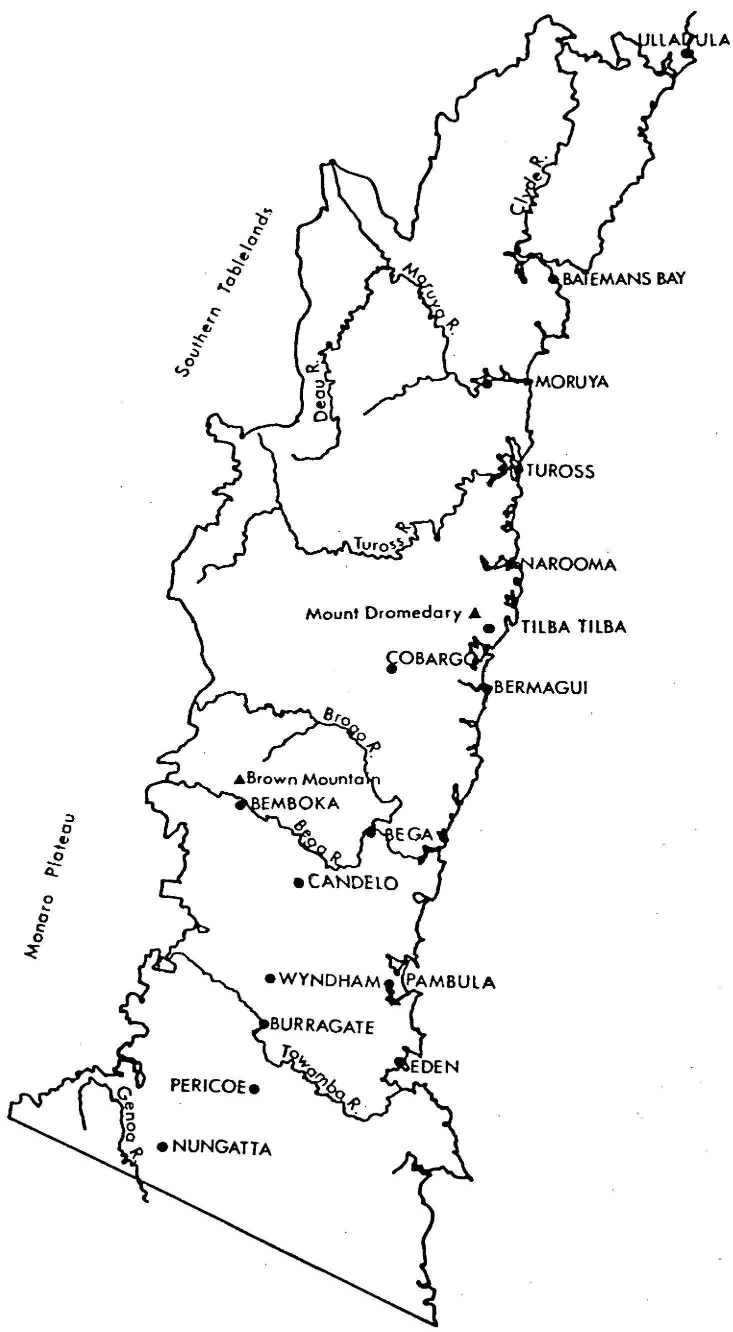

FIGURE 1.1 Map of the lower South Coast Region showing main centres of population and topographical features.

of the Region is covered by three complete shires - Eurobodalla, Imlay and Mumbulla. The western boundary is an escarpment about 50 km inland from the coast and separates the Region from the Southern Tablelands and the Monaro plateau to the west.

Three main topographical zones may be distinguished; (a) a mountainous belt along the escarpment, (b) a narrow coastal plain and (c) a relatively broad interconnecting area of hilly to mountainous country. Five major river basins occur. From north to south they are the Clyde, Moruya, Tuross, Bega and Towamba. Coastal lakes are a feature of the estuarine sections of several streams.

The physical environment has recently been described in some detail (Ryan, 1965, Water Conservation and Irrigation Commission New South Wales, 1966, 1968 and 1970a, b and c, Brown and Hogg, 1973). The climate is regarded as essentially sub-humid to humid temperate. Over much of the area south of the Clyde River the mean annual rainfall varies from 750 to 900 mm. Parts of the Bega and Towamba valleys are drier but annual rainfall typically exceeds 1,000 mm along the escarpment and the coastal fringe and particularly north of the Clyde River. In general, monthly rainfall is evenly distributed through the year, but wide fluctuations in both yearly and monthly rainfall distributions sometimes occur resulting in either severe floods or prolonged droughts.

Temperature is influenced by topographical location and proximity to the coast. Mean temperatures vary from 3^0 to 11^0C in the coldest month (July) and from 15^0 to 21^0C in the hottest (February). Extremely dry periods accompanied by hot northwesterly winds from the inland occur each summer causing serious fire danger and exacerbating the effects of the drought.

Although the geological pattern is quite complex (Packham, 1969) two formations predominate. The most important of these for farming includes the massive intrusions of the Bega, Moruya and Braidwood granites. The other is a broad band of Ordovician sediments. Major outcroppings of Upper Devonian sediments occur but are less extensive.

Until about 20 years ago the Lower South Coast Region was regarded as one of the more remote parts of coastal New South Wales, the main reason being relatively poor communications with other parts of the State. Never serviced by rail, the Region depended on coastal shipping during most of its development and more recently on road transportation. The relatively recent upgrading of roads has opened the Region for tourism and recreation. Highways now link the Region with the rapidly expanding urban areas of Sydney and Port Kembla-Wollongong to the north, with Canberra to the west and Melbourne to the south.

Over one third of the area is reserved as State Forest, publicly-owned land dedicated primarily for timber production. Another thirty percent is vacant Crown land for which no specific use has yet been prescribed, but the majority of it is under consideration for two major National Parks, one in the upper reaches of the Moruya and Tuross Rivers and the other in the Budawang Range. Private property, predominantly freehold land, makes up a third of the area. The balance (about 3 percent) is composed of National Parks, State Parks and Nature Reserves.

FARMING

Sporadic settlement commenced between 1820 and 1840. Beef cattle and sheep grazing and some cropping were the main initial land uses. Dairying became dominant later in the century and has remained so. In recent years dairy farming has been characterised by low incomes (Bureau of Agricultural Economics, unpub. data) and land use has been changing, chiefly to beef production.

Agricultural development has been fragmentary largely because of wide variations in geology, climate and topography within very short distances. Most farms are located on the undulating to hilly granite country of the Bega Valley and its tributaries. Other smaller farming areas are scattered through the Region, principally along the rich alluvial flood-plains of the rivers, on the granite soils in the catchments of the Towamba, Moruya and Tuross River systems, on basalt near the coast north of the Tuross River and on the hills of the Lochiel formation near Pambula. In general the farms replaced the tall woodland communities of forest red gum (*Eucalyptus tereticornis* Sm.) and rough barked apple (*Angophora floribunda* Sm.).

According to Longworth (1958) the farmlands in the Lower South Coast have suffered erosion as well as serious loss of fertility because of unsatisfactory farming practices. Not until the introduction of pasture improvement practices, a relatively recent development, was declining productivity and erosion arrested. Through the widespread application of superphosphate and the introduction of improved pasture species, farmers now obtain most of their stock feed requirements from pastures, rather than from intensive working of the land on a shifting agricultural basis as in the past.

As in other parts of Australia dairy farming in the Lower South Coast has been undergoing considerable adjustment with the number of producers declining from 482 in 1969/70 to 294 in 1974/75[1].

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1. Part of the following summary is based on information supplied by Mr. R.A. Whitelaw, Economist, Department of Agriculture, Goulburn.

Over the same period, the number of dairy factories fell from ten to four, and dairy cattle numbers from just over 53,000 to less than 42,000. Despite these reductions, total milk production has remained much the same but this has only been possible by ensuring all-year round fulfilment of quotas, which requires adherence to strict herd, pasture and farm management practices. There has been a noticeable trend to silage production, irrigation of pastures and improved pastures in an effort to increase production.

At the present time milk production is channelled either into the manufacture of butter and cheese or is supplied direct to the fluid milk markets at Canberra, Queanbeyan, Cooma, Sydney and the Region itself. Until as recently as 1971/72, however, more of the Region's milk was used for butter than either cheese or fluid milk, but in 1972/73 cheese became the dominant outlet. By 1974/75, approximately 40 percent of the Region's milk was utilised for cheese, 29 percent for fluid milk and most of the remaining 31 percent absorbed as cream for the manufacture of butter.

The majority of the cheese from the Region is manufactured by the Bega Cooperative Society Ltd. factory at Bega, which was supplied by 172 out of the 294 suppliers still remaining in 1974/75.

A small factory at Bodalla, the Bodalla Cooperative Society Ltd., also makes an important but smaller contribution. In 1975, butter was confined to two factories - the Cobargo Cooperative at Cobargo and the Bemboka Cooperative at Bemboka.

The future of the Bemboka Cooperative was then uncertain but agreement was understood to have been reached for it to supply the Bega Cooperative with wholemilk. As a result of the closure of the butter producing section of the Bega Cooperative during 1972/73, cream from that source is now supplied to Cobargo.

The main market for fluid milk is Canberra with most of the 17 million litres from the Region in 1974/75 being supplied by the Bega Cooperative. The Dairy Industry Authority of New South Wales also purchases milk from the Region for supply to the Sydney wholemilk market again principally from the Bega Cooperative, but the quantity involved is still quite small, totalling about 5.3 million litres in 1974/75.

The most noteworthy features of the dairy industry in the Region have therefore been the rapid decline of butter manufacture, the growing interdependence between the other cooperatives and the Bega Cooperative, and the increasingly dominant role being played by the Bega Cooperative in the Region. In 1974/75 Bega received an estimated 62 percent of all milk produced from the Region, compared with 52 percent in 1969/70.

Beef cattle numbers have risen rapidly in recent years with many of the marginal cream producers turning to this form of land use rather than continue in dairying. By 1969 there were more beef cattle in the Shires of Eurobodalla, Mumbulla and Imlay than dairy cattle and in 1972, the number of beef cattle had risen to 92,000 compared with 51,000 dairy cattle (Brown and Hogg, 1973). However because of the recent dramatic slump in world markets, prices for beef have been drastically slashed with the result that income from this form of land use has been seriously reduced. With rapidly rising costs and the high risk element injected into beef cattle grazing, the long term prospects for this industry in the Region must also be regarded with some uncertainty.

FORESTRY

Between 75 and 80 percent of the area still carries some form of natural vegetation varying in structure from depauperate sub-tropical rainforest to low heath (Hayden, 1971). Of this, approximately ninety percent is forested.

Dry and wet sclerophyll forests are by far the most widespread and are dominated almost completely by species of the genus Eucalyptus. The forests have been highly modified, particularly following European settlement, and cannot now be regarded as truly natural plant communities. Fire and man have been the main factors influencing the pattern, stability and structure of the forests. Repeated severe wildfires have, in conjunction with earlier unregulated low intensity logging, altered the characteristics of the natural stands.

Long term forest management on a sustained yield basis has been confined chiefly to State Forests in the northern half of the Region. However the recent reservation of large areas of Crown lands as State Forests in the southern part presented the opportunity to bring a further substantial area of the forest resource under planned management.

Commercially, spotted gum (*Eucalyptus maculata* Hook.) types are most significant in the northern part of the area while in the south the stringybarks (*E. globoidea* Blakely, *E. agglomerata* Maiden, and *E. muellerana* Howitt) and silver top ash (*E. sieberi* L. Johnson) predominate. Messmate (*E. obliqua* L'Herit) - brown barrel (*E. fastigata* Dean ex Maiden) - mountain grey gum (*E. cypellocarpa* L. Johnson) types become more prominent in the vicinity of the coastal escarpment.

In more localised situations where rainfall is mostly uniform, topography and aspect probably constitute the major factors influencing the potential productivity of a forest site. The most productive forest types are usually associated with the lower, more sheltered slopes of south to east aspect while the least productive are found on the upper parts of the steeper slopes, particularly of north to west aspect.

Output from the forests has risen sharply in recent years especially since the commencement of the woodchip export project in 1968 which is centred on a chipmill at Edrom on the southern side of Twofold Bay. While most of this increase was due to the woodchip project there has been a noticeable increase in sawlog production. Although precise production figures for the Region are not available, it is possible to provide some indication of production trends by aggregating statistics on production from the South Coast and South East Forestry Districts reported each year by the Forestry Commission of New South Wales in its Annual Reports, since the bulk of the output from these two areas originates from the Region.

In 1973/74 these two districts provided 329,859m^3 or 16.1 percent of the total output of sawlogs from New South Wales, 49,819m^3 or 32.3 percent of the mining timber and

405,271 m^3 or 66.9 percent of the pulpwood (Forestry Commission of New South Wales, 1974). Prior to 1968, there was no production of pulpwood. Sawlog production rose from about 225,000 m^3 in the early 1960's to the above figure of 329,859 m^3 in 1973/74, while mining timber has remained relatively stationary around 45,000 m^3 with the exception of the record production level of 54,800 m^3 in 1969/70.

Although the proportion of the total production of sawlogs from Crown lands has remained relatively constant at about 70 percent since the early 1960's, future supplies from private property are expected to decline. Private property has also made a significant contribution to pulpwood supplies with 114,782 m^3 produced from this source or 27.5 percent of total output from the two districts. Over half the production of mining timber is harvested from private property but there has been a decline in output from this source in recent years from the record levels of the mid-sixties.

The Region is therefore extremely important to New South Wales since more than 20 percent of total roundwood production originates from it. While most of this production originates from the indigenous eucalypt forests, softwood plantations are being established in the southwest by both private and public interests. The annual planting rate is currently 2,400 hectares of which 1,600 hectares is being carried out by the Forestry Commission of New South Wales. Although the plantations only play a minor role at present, their contribution to future wood supply will be significant.

Because the planting programme carried out by the Forestry Commission of New South Wales involves the clearing of eucalypt forest on State Forests, it has been strongly criticized on environmental grounds (Routley and Routley, 1973). By contrast the privately owned planting project is confined to farmlands, much of which is, or has been, already cleared; not unexpectedly, there has been little criticism of this operation.

THE ANALYTICAL MODEL

The foregoing descriptions of farming and forestry indicate that there are areas of marginal farmland in the Region capable of being used for exotic pine plantations. This study is therefore an attempt to develop an analytical framework within which marginal farmland might be integrated into the Regional wood supply situation in such a way that some of the conflicts which have arisen over forest land-use might be resolved. The purpose of the model is to determine whether and to what extent society should undertake investments in the conversion of marginal farmlands to plantations for wood production. The framework consists of two sections - the first, an economic comparison of farming and forestry in order to delineate those areas where forestry is more efficient than farming, and the second, a large linear - programming model of wood production for the whole Region, including farming areas identified in the comparative analysis as being economic for this purpose.

The main goal of the study is to maximize the welfare of society by means of wood production from the Region. The criterion by which welfare is measured is the present value[2] of the net social benefits generated. It represents the difference between social benefits and social costs appropriately discounted at society's social rate of discount. The objective function is the maximization of this criterion within a linear programming framework. The study is therefore based on the principles of cost-benefit analysis, an analytical technique considered to be particularly appropriate to most forms of land-use investigations (Ferguson, 1974a).

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2. Internal rates of return could be adopted instead but for various reasons represent a less reliable criterion (Henderson, 1965) and involve difficulties for much of the public forest. Market prices for most of the public forestland are generally not available and opportunity cost must be imputed using the Faustmann approach. Thus derivation of the true internal rate of return would require prior estimation of the present values. (See Bentley and Teeguarden, 1965.)

An important feature of the criterion used is that it is based on social benefits and costs. Thus it is not those revenues and costs accruing to the individual or institution making the decision over the use of the land which are relevant (the private benefits and costs) but rather those borne by the community or the nation as a whole.

The study deliberately sidesteps the difficult problems of multiple goals even though there have been some important advances in this field in recent years (Cassidy and Kilminister, 1975). The applications of linear programming in the manner described by Candler and Boehlje (1971), for example, was considered as one means of explicitly incorporating multiple objectives into planning models. Goal programming is another possible tecnique which has been used by Field (1973) in the planning of a small tract of privately-owned forest, by Edgar (1974) in the development of regional policies for public land-use using a simplified representation of the public lands of south-western Victoria, and by Porterfield (1974) for computing gains from tree-improvement programmes in loblolly pine (*P. taeda* L).

Because of the difficulty of assigning suitable weights to goals and the large number of projects and hence goals proposed, neither of the two previous methods was considered appropriate to the present study.

Ideally, of course, the formulations of economic models for application to land-use planning situations should incorporate all possible land uses. The problem is that some of these uses (e.g. wilderness use) cannot be readily valued in terms of the social benefits involved. Nevertheless, in areas where forests assume major importance, such as the Lower South Coast Region, the development of a model based on net social benefit in terms of wood production alone will enable the valuation of large tracts of land for other uses in terms of their opportunity cost. While this is admittedly an incomplete guide for land-use planning it does represent a useful starting point with respect to other uses of the forest.

This method was proposed by Duerr and Vaux (1953) for application to forestry situations but it has only been in recent years, particularly with the growing concern for the environment, that the approach has received wider attention (see, for example, Dargavel and Ferguson, 1975; Ferguson, 1974; Ferguson and Reilly, 1975; Gibson, 1971; Manning, 1971).

Throughout the study, wood production is assumed to encompass three commodities - pulpwood, sawlogs and mining timber. Production possibilities involving any one or all of these commodities in any part of the Region are dictated largely by the physical limitations of the land on the type of wood produced.

Administration of the forest estate is assumed to be carried out by the Forestry Commission of New South Wales, the government instrumentality responsible for the management of timber production from publicly-owned lands in the Region. This responsibility extends also to plantations established in the farming areas.

Each stage of the study consisted of the five steps advocated by Gibson (1971) for investigations involving optimal land-use planning:-

(1) an inventory of the resource,

(2) definition of supply alternatives,

(3) development of input-output models,

(4) estimation of aggregate demand,

and (5) analysis of the optimum allocation of resources.

The first step in the comparative analysis of farming and forestry therefore comprises a forest land capability survey of the farmlands in order to determine their potential productivity for wood production. Supply alternatives were then specified for the three land uses being compared; that is, the production strategies for each land-use. Inputs and outputs for each supply alternative were derived from a variety of sources including production functions, cross-sectional analyses, average data from comparable activities within the Region or average data from similar activities elsewhere. At all times it was assumed that any changes in production from the three land uses would be unlikely to exert any impact on aggregate supply and demand and thus prices were assumed to remain unchanged, except where otherwise stated. The land-use giving the maximum present value of the net social benefits per hectare was deemed to be the most efficient.

The linear-programming model of forest production from the Region follows much the same route, the main differences being that the specification of supply alternatives was confined to wood production only and that the optimal set of strategies is determined within the constraints defined by the linear-programming model.

In developing both the comparative study and the linear-programming model, consideration was also given to structural changes in industries of relevance to the three land uses in the Region. For example, in line with past experience, the number of hardwood sawmills was assumed to continue to decline. Because of rising labour costs sawmills were expected to become more capital intensive with the passage of time.

The starting year for planning was assumed to be the mid-point of the period 1975/76 to 1979/80. Two separate planning horizons were adopted:-

(a) a linear programming planning horizon of 50 years which represents the limit of time during which constraints are identified explicitly in the model; and

(b) an investment planning horizon in which changes in the constraints beyond the 50-year linear programming planning horizon are ignored. But because land will continue to produce after 50 years, the specifications for each strategy are extended to a point where a steady-state schedule of inputs and outputs is entered into, thereby avoiding the necessity to place a terminal value on the land at the end of the 50-year planning horizon. Thus the investment planning horizon is set at infinity and is relevant to both the comparative analysis and the linear programming model in the determination of the present value of the net social benefits per hectare for all production strategies.

Except where otherwise indicated, all costs, prices and interest rates, were assumed to be measured in "real" magnitudes relative to the purchasing power of money at some specified date. The year 1972/73 was adopted for the purposes of this study. This assumption obviates the necessity of trying to estimate future rates of inflation, an especially difficult task at the present time.

A world of certainty was also assumed to prevail in developing the analytical models. However, because of the extremely long planning horizons, uncertainty obviously has an important influence on the evaluation of the supply alternatives in both parts of the investigation and therefore cannot be dismissed. An evaluation of the impact of changes in parameters likely to influence future outcomes was therefore considered to be relevant. In the case of the comparative analysis, this involved testing the sensitivity of each land-use to changes in prices, discount rate and structural change. Because of the size of the linear programming model and the limited time available, sensitivity testing was not carried out in this study. However, in constructing the model, it was considered important to ensure that it was capable of being used for sensitivity testing covering a wide range of situations, particularly through the constraints.

STRUCTURE OF THE THESIS

The investigation is divided into two main parts: Part I, the comparative analysis of farming and forestry in the farmlands of the Lower South Coast; and Part II, the development of a linear programming model for the identification of the optimal set of production strategies for wood production from the Region.

CHAPTER 2

POTENTIAL PRODUCTIVITY OF THE FARMLANDS FOR FORESTRY AND FARMING

Because dairying and beef grazing have been practiced in the Region for more than a century, the capability of the farmlands, under either use, is reasonably well-known. On the other hand very little is understood of the potential for forestry there. Before an economic comparison of the three land uses can be undertaken it must first be shown that there are suitably-located areas of farmlands which are technically capable of growing suitable plantation species.

A broad-scale survey of the farmlands was undertaken for this purpose in 1973, the results of which were published recently (Reilly et al., 1975). The primary aims of the survey were, firstly, to classify broadly the potential productivity of the farmlands for plantations of radiata pine, and secondly, to delineate suitable blocks of predominantly marginal farmland. A further objective was to gain some indication of the pattern of land-use in the Region and the farming methods being employed.

Thus in this chapter it is proposed to outline the survey procedure adopted and to present the findings of the survey. In addition, some indication of the productivity of the farmlands for dairying and beef grazing is provided.

THE POTENTIAL PRODUCTIVITY OF THE FARMLANDS FOR RADIATA PINE PLANTATIONS

The ensuing discussion is based on the paper by Reilly et al. (1975). It was directed primarily at defining the potential of the farmlands for radiata pine plantations and at identifying any pockets of marginal farmlands which would be suitable for this purpose.

Soils of the Farming Areas

Little detailed information on the soils of the farming areas is available. Soil associations as far south as Cobargo have been mapped and related to existing land use (Walker, 1960) but for districts further south data are less substantial (Northcote, 1962). The most fertile and most intensively cultivated soils are the alluvial soils along the major coastal streams south of the Clyde River, particularly the Moruya and Tuross Rivers. They are described by Walker (1960) as deep prairie soils and by Northcote (1962) as deep porous loamy soils of uniform texture.

Northcote (1962) describes the soils of the hilly farming areas on Bega and Moruya granite as predominantly brown and red friable earths (soils with gradational texture profiles) in association with hard acidic yellow mottled soils, hard acidic red soils and yellow leached earths all of which exhibit podzolic profiles. These soils are underlain to considerable depth by a gravelly admixture derived from decomposed granite.

Walker (1960) reported these granite hill soils as having moderate to poor tilth which tends to deteriorate under cultivation. He also rated them as some of the poorest chemically, particularly in phosphorus and sulphur and, to a lesser extent, molybdenum and copper. Holmes (1961) reported extremely low butterfat yields from similar granite soils in the Moruya area amounting to only one sixth the yield from recently deposited alluvial soils.

Further studies of soils in the Imlay Shire, including the southern section of the Bega Valley and the Pambula and Towamba Valleys, also gave low fertility ratings particularly the yellow podzolic soils (Lofts, 1960).

Soils on the Braidwood granite in the upper reaches of the Moruya River at Araluen belong primarily to the deep massive earths and in contrast to the other granite soils of the Region appear to be of moderately high fertility (Gunn, 1969).

Measurement of Woodlots

The studies cited earlier suggest most granite-derived hill soils in the Region are likely to be poor chemically, especially in phosphorus. Studies carried out by the New South Wales Department of Agriculture in the Bega area also indicated low amounts of available phosphorus, 3 to 6 ppm being typical in samples of the top 10 cm of soil under unfertilized native pastures. Annual dressings of 150 to 300 kg/ha of superphosphate are needed to maintain improved pastures at a desirable level of 25 to 30 ppm of available phosphorus.

Since the implications of these findings for tree growth are not clear, radiata pine woodlots and wind-breaks in the Region were measured to provide a better basis for a land capability survey.

Stand top height, defined as the mean height of the tallest 40 trees per ha, was measured on more than 20 plots of radiata pine. The age of the stand was ascertained from farm records where possible or from increment borings. The height/age relationships (Cosco, 1971) developed for radiata pine plantations in New South Wales were then used to estimate site index, defined as the average height of the tallest 40 trees per hectare at age 20 years. Whilst the reliability of these relationships for values of site index below 19 is questionable this has little affect on this study.

The estimated site index and the site characteristics of the eleven woodlots or windbreaks which most closely approximate plantation conditions are given in Table 2.1.

TABLE 2.1

Site Index of radiata pine woodlots in the Lower South Coast Region of New South Wales

Woodlot No.	General location	Age (yrs.)	Mean annual rainfall (mm)	Topographical position	Aspect	Predominant slope	Site index (metres)
1	Bemboka	35	820	Mid-to-lower slope	NW	$3\text{-}8^0$	21
2	Brown Mt.	17	850+	Upper slope	S	$3\text{-}8^0$	23
3	Polock's Flat, Bemboka	13	850	Crest	S	3^0	19
4	Candelo	22	740	Upper	W	$3\text{-}8^0$	17
5	Candelo	14	740	Mid-slope	E	$3\text{-}15^0$	20
6	Candelo South	14	740	Lower-mid slope	W	$3\text{-}8^0$	19
		14	740	Mid-slope	W	$3\text{-}8^0$	21
		14	740	Upper slope	W	$3\text{-}8^0$	20
7	Candelo South	13	740	Crest of steep	Crest	$3\text{-}8^0$	18
8	Burragate	12	740+	Mid-slope	SE	$3\text{-}8^0$	26
9	Pericoe	5	810+	Lower slope	NE	$3\text{-}8^0$	28+
10	Burragate	50-55	740	Old river terrace	Flat	level	23
11	North of Cobargo	22	900+	Crest	Crest	level	21

Radiata pine is particularly vulnerable to grass competition during early development (de Boer, 1970) and it is unlikely that cultivation or other measures to reduce grass competition were carried out in these woodlots. In some instances, planting stock apparently originated from transplants of natural regeneration from older trees in the area and early growth and survival could have suffered. Nutrient deficiencies and stock damage were also evident in several woodlots. Thus the woodlots probably reflect the capacity of the land to grow radiata pine under the least favourable conditions of establishment and maintenance. Commercial plantations on the same sites should achieve better results.

About half of the woodlots had site index values of at least 21 m, which is considered to be the minimum level for large-scale commercial plantations. However, for reasons outlined previously, most of the woodlots probably give lower values of site index than would be obtained had commercial plantations been established. The results are best regarded as providing a relative guide to the effects of rainfall and topographic characteristics of the area on tree growth. Taken overall the results generally show that site index increases with increasing rainfall but declines on the upper slopes and crests.

The plantations established by the Forestry Commission of New South Wales at Bondi and Nalbaugh State Forests probably provide a better guide to the potential for tree growth on granite soils in the Region. These plantations have been established on soils derived from Bega granite on the edge of the plateau in the extreme southwest of the Region. Site index ranges from 21 to 34 m (Forestry Commission of New South Wales unpublished data). There is little evidence of phosphorus deficiency. Rainfall is also higher and more reliable than in the farming areas, averaging 940 mm per annum so that the high site index recorded in these plantations is not unexpected.

Classification System

Without extensive field trials the determination of land capability for radiata pine was necessarily based on a subjective mixture of the results of other surveys, woodlot measurements, existing plantations and personal judgment. A consistent system of classification is essential so that future studies can gauge the worth of the system or adapt it in the light of further experience. Thus the following procedure was adopted:-

TABLE 2.2

Land categories identified in the farming areas of the Lower South Coast Region of New South Wales

Category	Description
(a)	Deep colluvial soils of the lower parts of the escarpment and steeper slopes.
(b)	Well drained deep alluvial soils not subject to flooding such as old raised flood plains and river terraces.
(c)	Soils of undulating to hilly topography on Braidwood granite.
(d)	Soils of undulating to hilly topography on basalt.
(e)	Soils of undulating to hilly topography on Mount Dromedary monzonitic granite.
(f)	Soils of undulating to hilly topography on Bega and Moruya granites.
(g)	Soils of predominantly hilly topography on sediments and meta-sediments.
(h)	Alluvial soils subject to frequent flooding and poorly drained.

(1) The farmlands were firstly split into well defined districts or "farming areas", on the basis of location and historical development. The farming areas were then subdivided very broadly into a number of "land units" on the basis of topography, climate, geology and soils.

(2) Each land unit was classified into one of eight categories according to soil, topographical and geological characteristics (Table 2.2).

(3) A site index was then assigned to the land unit on the basis of its mean annual rainfall (Table 2.3).

TABLE 2.3

Site Index allocated to land categories according to mean annual rainfall

Land Category from Table 2.2	Site Index (m) by mean annual rainfall classes (mm)				
	900+	800-900	700-800	600-700	Less than 600 mm
(a)	33	30	27	24	21
(b)	33	30	27	24	21
(c)	30	27	27	-	-
(d)	27	24	-	-	-
(e)	27	24	-	-	-
(f)	27	24	21	21	18
(g)	27	24	21	18	18
(h)	Low Site Index				

(NOTE: The natural capacity of the sites is indicated, not their site index with fertilization.)

The procedure adopted in constructing Table 2.3 can most readily be explained by reference to the dominant land category (f), which embraces the soils of undulating to hilly country on Bega and Moruya granites. The maximum site index on these soils was estimated to be between 27 and 30 m, based on site index estimates of the established radiata pine plantations at Nalbaugh and Bondi State Forests where mean annual rainfall exceeds 900 mm. Therefore for typical farming areas on category (f) lands receiving more than 900 mm rainfall per annum the potential site index was conservatively fixed at 27 m. Category (f) lands receiving between 600 to 800 mm per annum rainfall were assigned site index 21 m, based on the measurements of the Candelo South woodlots (No. 6). For areas of 800 to 900 mm and less than 600 mm rainfall, the site index was estimated by simple linear extrapolation.

Category (a) lands were based on woodlot No. 9 at Pericoe in the Towamba Valley and on Duffy's (1969) land capability classification.

The assignment of site indices to category (c) lands was based initially on the forest land capability classification of the Bettowynd and Araluen land systems in the Queanbeyan-Shoalhaven survey (Duffy, 1969). Duffy's classification appeared to overestimate the real capability of these lands (based on observations of radiata pine growing in the Araluen area) and somewhat lower values were assigned in this classification.

The remaining land categories were value-judgments based on the limited observations relating to each category and extrapolating from the more substantial data of the other land categories. Sections of the table not having a site index did not exist anywhere in the farmlands of the Region.

(4) The site index determined in (3) was then modified where necessary on the basis of other factors. An important factor was aspect. In undulating to rolling hill country, no change was usually made to the site index derived. In the steeper hill areas, site index was upgraded 1.5 where slopes were facing south or southeast, while for west and northwest slopes, it was downgraded 1.5.

Further adjustment was made according to slope position in the steeper country. Where a land unit was located principally on an upper slope, the site index was downgraded 1.5 while on lower slopes it was upgraded 1.5.

(5) Local factors such as erosion, altitude, flooding etc. were also considered where relevant and appropriate adjustments made to the site indices derived in (4). Areas above 300 m altitude were upgraded 1.5. Soils subject to flooding were downgraded to a site index of 18 metres while badly eroded soils were downgraded 3. Areas where rock outcropping was prevalent were downgraded 3. With the exception of altitude and flooding these other factors were limited to relatively small areas.

Marginal farming areas were identified by the condition of farmhouses, buildings, fences and pastures. Where these were predominantly rundown, the lack of maintenance was assumed to reflect low levels of income. This classification is admittedly very crude but it must be remembered that the objective was to delineate large blocks of predominantly marginal farmland.

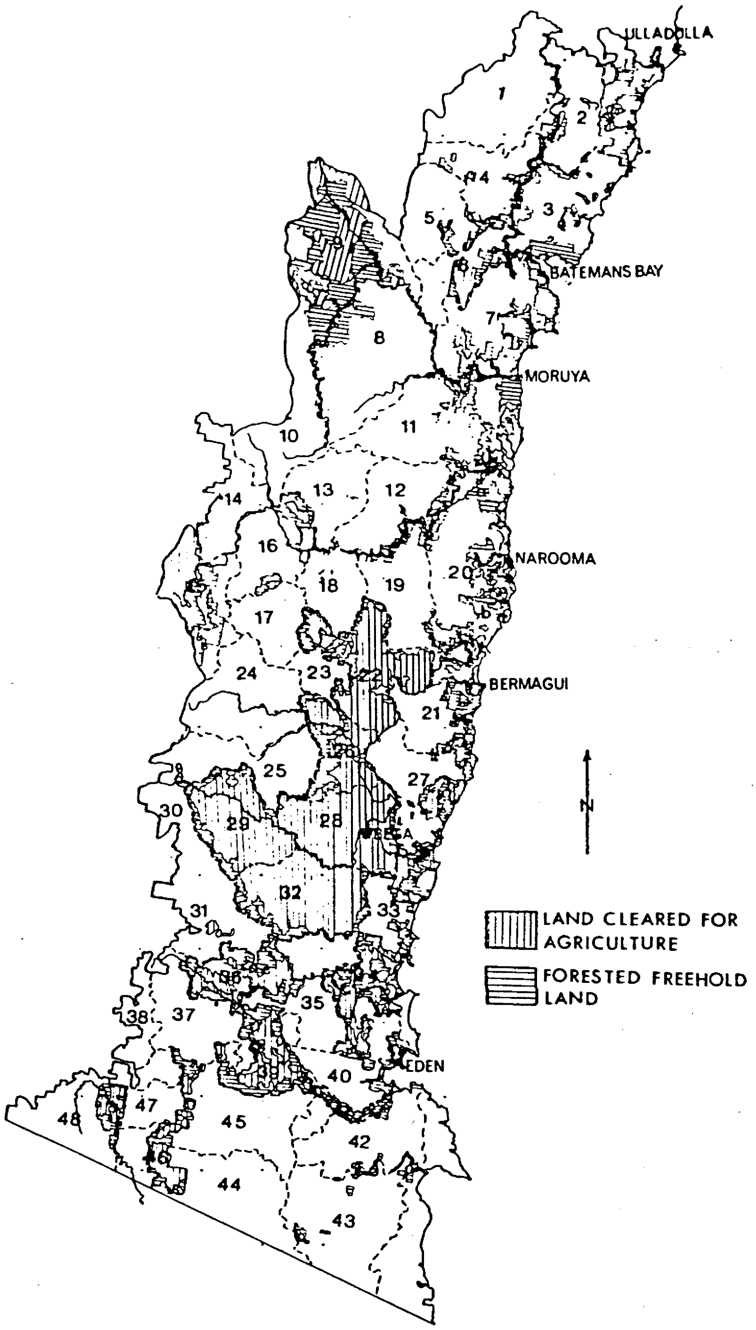

FIGURE 2.1 Map showing Management Areas (MA) in the lower South Coast Region. Management Areas are shown within the boundaries marked by the broken lines (--------) and can be identified individually by their respective numbers.

Araluen MA – 9; Bega MA – 28; Bemboka MA – 29; Bodalla-Tilba MA – 20b; Bodalla-Tuross MA – 20a; Bondi MA – 48; Buckenbowra MA – 6; Burragate MA – 39; Candelo MA – 32; Cobargo MA – 22; Lower Brogo MA – 26; Mogo MA – 7; Moruya MA – 11; Nungatta MA – 46; Pambula MA – 34; Wyndham MA – 36; Nalbaugh and Coolangabra State Forests are located in the MA designated by 38 while Bondi State Forest is included in Bondi MA.

The criteria used to identify a marginal farm may well be misleading in the case of a farmer who, though earning ample net income, prefers not to spend it on maintenance. However, as indicated earlier, past surveys (Bureau of Agricultural Economics unpublished data) have shown that a high proportion of dairyfarmers in the Region do have low levels of net income. It therefore seems unlikely that this potential source of error resulting from basic differences in farmers' preferences will influence the identification of large blocks of predominantly marginal farmland.

Results

The survey was necessarily extensive rather than intensive in nature. Considerable use was made of aerial photographs, soil maps and other surveys to supplement the field reconnaissance of the farming areas.

Land units have been amalgamated into larger units called Management Areas to facilitate discussion of the findings of the survey and to suit the requirements of the larger land use investigation being carried out. The Management Areas correspond roughly with well-defined farming districts in the Region. Where a Management Area includes more than the farming district, the district has been separately designated by its common name in the results, e.g. the Tilba farming district in Bodalla Management Area is designated by "Bodalla-Tilba". The boundaries of the Management Areas are also shown in Figure 2.1.

Except for the Araluen Management Area, less attention has been directed to farming districts north of Narooma because the potential for large-scale forestry development there is limited, there being only relatively small areas of marginal farmland. Therefore most of the following discussion relates to the farming districts south of Narooma, particularly those located in the Shires of Mumbulla and Imlay.

A summary of the results in terms of the proportion of each Management Area within site index classes, 3 m wide, and the weighted average site index of each Management Area is shown in Table 2.4.

TABLE 2.4

Survey results for farmlands in the Lower South Coast area of New South Wales

Management area	Map No.	Mean annual rainfall (mm)	Developed farmland (1,000 ha)	Proportion of developed farm land in each site index SI 18	SI 21	SI 24	SI 27	SI 30	Weighted average site index
Araluen	9	800-900	12.0	-	5%	10%	55%	30%	27.3
Bega	28	900	25.0	10%	35%	40%	15%	-	22.8
Bemboka	29	815	20.0	10%	30%	35%	20%	5%	23.4
Bodalla-Tilba	20b	900	3.0	10%	15%	40%	35%	-	24.0
Bodalla-Tuross	20a	800-900	.8	-	100%	-	-	-	21.0
Bondi	48	900+	1.9	-	-	20%	40%	35%	27.4
Buckenbowra	6	800-900+	2.4	-	10%	35%	40%	15%	25.6
Burragate	39	700-800	7.7	25%	30%	30%	10%	5%	22.2
Candelo	32	600-900	25.0	15%	35%	40%	10%	-	22.4
Cobargo	27	800-900	21.0	-	10%	40%	45%	5%	25.4
Lower Brogo	26	900	10.0	5%	25%	50%	20%	-	23.6
Mogo	7	800-900+	2.0	60%	-	20%	20%	-	21.0
Moruya	11	800-900+	4.0	5%	20%	50%	25%	-	23.9
Nungatta	46	900	4.8	-	15%	40%	35%	10%	25.2
Pambula	34	800-900	7.0	20%	40%	30%	10%	-	22.2
Wyndham	36	750-900+	7.4	10%	30%	35%	15%	10%	23.6

Based on the weighted average site index, the Management Areas with the highest potential productivity are Araluen, Bondi, Buckenbowra, Cobargo and Nungatta. Parts of the remaining areas also rate highly, notably Bemboka, Burragate, Lower Brogo, Bodalla-Tilba and Wyndham Management Areas.

Generally Management Areas in the higher rainfall and higher altitude zones have the most potential, e.g. Araluen, Bondi, Cobargo and Nungatta, while those near the coast on the lower reaches of the rivers and of lower rainfall, and which have been farmed intensively for over a century, were regarded as having a greater proportion of sites with lower indices (less than site index 24). On the whole, the farming areas averaged at least site index 21 and in some were as high as site index 27. Therefore the prospects for plantations were considered to be very promising.

The best sites for radiata pine were found to coincide roughly with the marginal farming areas identified by the procedure outlined earlier. These include the Management Areas of Bemboka, Bondi, Cobargo and Wyndham. Marginal farming areas in Burragate and Pambula Management Areas were not so impressive but still averaged site index 22.2 overall. The most suitable marginal farming areas for forestry purposes are Bondi and Cobargo Management Areas, both of which should achieve a site index of approximately 27 m (a mean annual increment of about 21 m^3/ha).

The marginal farming areas also tended to be located in the vicinity of the butter factories at Bemboka, Cobargo and Pambula. Such a pattern is not surprising in view of the decline in the real price of butter over the past decade (Bureau of Agricultural Economics, 1974). Even in the more isolated, former cream-producing areas such as in Burragate and Wyndham Management Areas where an almost complete change to beef grazing has taken place, incomes did not appear to have improved substantially as a result of the change.

The loss of much of the A1 soil horizon through past farming practices may lead to problems of soil moisture availability in the early years following establishment of radiata pine. Experience elsewhere in Australia suggests that this problem could be overcome by deep ripping along the planting rows or total cultivation, possibly combined with ridging (Brown, 1971). Complete ploughing will probably be needed in any case to reduce the competition from pasture species and is currently being used successfully by Kapunda Development Co. Pty. Ltd. in the conversion of farmlands to radiata pine plantations in the vicinity of Nalbaugh and Coolangubra State Forests.

Field trials of fertilizers are needed to determine the response of trees growing on various soil types and the optimum rates of fertilizer application. In the land capability survey it was assumed that fertilizers would not be used because too few data were available on the results of adding fertilizers. Experience elsewhere in New South Wales (Gentle, 1971) has demonstrated dramatic responses to phosphatic fertilizers on land of otherwise low site index and this response should be sustained (Forrest, 1969) through the rotation.

The survey established that the farmlands of the lower South Coast Region seem capable of supporting plantations of radiata pine of high potential productivity. The minimum site index achievable under conditions of establishment used in commercial plantations was estimated to be 21 metres, with most areas capable of averaging site index 24.

The more promising areas for forestry were located in the major marginal farming areas particularly in the vicinity of Bemboka and Cobargo, in the Pambula-Towamba valleys and in the upper reaches of the Genoa River near Bondi State Forest. Altogether more than 70,000 ha of farmland were included in these areas of which the major part is considered to be marginal for farming under present conditions.

DAIRYING AND BEEF GRAZING

No attempt was made to classify the farmlands in terms of their present capability for dairying and beef grazing since this aspect was covered sufficiently for the requirements of this study by Brown and Hogg (1973) in an earlier investigation. Their study involved, firstly, subdividing the farmlands into a number of small, relatively homogeneous land units called "blocks" and then subjectively assigning a rating between zero and ten for each of the parameters considered likely to influence the suitability of the block for either use. An average rating for the block was derived by weighting each parameter and aggregating the weighted values.

Although the suitability of the farmlands could be ranked by this procedure, it was not possible to arrive at any estimate of productivity. Therefore Brown and Hogg's study has been used to establish major variations in suitability with estimates of productivity based on other surveys.

Dairying

Brown and Hogg (ibid.) concentrated on parameters which were likely to affect pasture growth although location to markets and the extent of usable land in each block were also considered. Their findings showed that with the exception of the eastern part of Bega Management Area and the southern section of Cobargo

Management Area both of which were rated as good for dairying, the suitability of the farmlands generally could only be regarded as fair to very fair for dairying. The main limiting factors were considered to be the steep nature of much of the granite hill country in which most of the dairying areas are located and marginal rainfall. The most poorly rated Management Areas were Burragate, Moruya, Pambula and Wyndham. When these relatively low ratings are considered in the light of the economic problems experienced by the dairy industry in Australia, it is not difficult to understand the reasons for the changing pattern of land use in the Region in recent years.

The potential productivity of the Region's farmlands can be approximated from the results of the Australian Dairy Industry Survey for the period 1967-68 to 1969-70 (Bureau of Agricultural Economics, unpublished data). It was found that while productivity per cow for the Region (2,392 litres per annum) was the second lowest in the State (see Table 2.5), on a per hectare basis it was second only to the predominantly wholemilk-producing area of Sydney-Illawarra. This infers a higher carrying capacity which is surprising in view of the relatively small area of potentially irrigable land in the Region as compared to the rest of the State (see Table 2.6). One possible explanation seems to be the relatively high proportion of each farm converted to some form of improved pasture (again see Table 2.6).

TABLE 2.5

Average production per cow and per hectare by Regions and for the State of New South Wales over the period 1967-68 to 1969-70

Region	Production in Milk Equivalents (litres)	
	Per Cow	Per Hectare
Lower South Coast	2,392	1,514
North Coast	1,853	1,081
Hunter-Manning	2,537	1,334
Out Sydney-Illawarra	3,112	2,615
Murray	2,787	1,414
Whole State	2,358	1,354

(Source:- Bureau of Agricultural Economics (unpublished data).)

TABLE 2.6

Average area of irrigable land, improved pasture and native pasture per farm by Region and the whole State of New South Wales for the period 1967-68 to 1969-70

Region	Irrigable Land		Improved Pasture		Native Pasture		Total Area
	ha	%	ha	%	ha	%	ha
Lower South Coast	5	4	73	57	41	32	127
North Coast	12	10	44	37	67	57	118
Hunter-Manning	14	10	52	35	80	54	147
Outer Sydney-Illawara	16	15	67	63	20	19	107
Murray	72	42	96	56	37	22	172
Whole State	16	12	54	41	64	48	132

(Source:- Bureau of Agricultural Economics (unpublished data).)

Productivity figures for the Region therefore appear to be very much dependent on the area converted to improved pasture. However it is not the only factor influencing production since wide variation also occurs within and between years. For example, the Australian Dairy Industry Survey showed that peak production occurred in early summer thereafter falling to less than half this peak level in winter. Between year variations are almost wholly dependent on rainfall and reflect the Region's reliance on dry farming methods.

In the typical dry farming areas which predominate in the Region and which represent the main areas of interest for conversion to plantations, it was assumed that productivity does not vary greatly between areas assuming the same level of technology and managerial skill is used on the farm.

Thus productivities can be based on average data for the Region as a whole from the results of the Australian Dairy Industry Survey without any need for distinction between individual farming areas. On the basis of the Survey's findings, it was concluded that farms with mostly improved pastures were capable of productivities ranging between 2,500 and 3,500 litres per cow per annum on the average while for less developed properties productivities less than 2,500 litres were more common.

Beef Grazing

In general Brown and Hogg's system of ranking resulted in much the same pattern of suitability as that found in dairying, the main difference being the generally higher suitability ratings for beef grazing. The observations recorded during the forest land capability survey tended to confirm these rankings with the less suitable dairying areas, particularly those more remote from the Bega Cooperative, changing rapidly to beef grazing. Again the productivity of the farmlands for beef production was assumed to be reasonably uniform throughout depending more on the type of pasture, level of management and farm size. Carrying capacities on native pastures typically average one breeding cow (or two steers) per 3.6 hectares compared with one breeder to 1.2 hectares of improved pasture, based on data supplied by the Department of Agriculture, Bega and on information collected by the author during visits to properties in the Region.

CONCLUSIONS

On the basis of the findings of the land capability survey, the farmlands of the Region appear to be better-suited to beef grazing and forestry (in the form of radiata pine plantations) than to dairying. The areas of most potential for dairying are typically located in close proximity to Bega, the main centre for utilisation for milk, with access to an all-year round water supply for irrigation purposes. As a general rule, the main marginal dairy farming areas tended to be the most productive potentially for radiata pine plantations but much of this country has already been converted to beef grazing. Therefore for radiata pine plantations to be considered as a land-use alternative in these areas, it must be shown that they are not only more economic than the traditional land-use, dairying, but also more economic than beef grazing. Furthermore, ways of satisfactorily integrating forestry into the existing land-use situation need to be developed.

CHAPTER 3

THE ANALYTICAL FRAMEWORK

INTRODUCTION

This study is based on the principles of underlying social cost-benefit analysis. These principles have been the subject of numerous reviews and surveys; notably Prest and Turvey (1965), Little and Mirrlees (1968), Mishan (1971), Dasgupta et al. (1972), Layard (1972), Lal (1974) and van der Tak and Squire (1975). Ferguson (1974) and Cassidy and Gates (1978) provide reviews which are more specifically addressed to the problems relating to agriculture and forestry. Although an exhaustive review of the subject would be redundant in the light of these publications, a brief outline of the general principles adopted is necessary. More detailed discussion of the methods employed in this study is also provided.

GENERAL PRINCIPLES

The distinction between social and private values merits some elaboration. If the prices of all inputs and outputs were established in perfectly competitive markets free from externalities, the financial values of those prices would also be valid social values, because they would reflect the marginal valuations of consumers and of producers. However, a number of imperfections exist in the markets under consideration and others may cause the social values to differ from the financial values established in these markets. Where the divergence seemed likely to be substantial, shadow prices were imputed for the input or output concerned and these shadow prices formed the basis for the calculation of social benefits or costs. In all cases, however, valuation for a particular form of land use was based on the "farm gate" or "at stump" values (Ferguson, 1974).

Valuation was also carried out in terms of units of aggregate consumption (Dasgupta et al., 1972), not units of aggregate investment (Little and Mirrlees, 1968). The distinction is largely a matter of convenience, the two methods ultimately yielding identical results.

All costs and benefits were estimated in "real" values, relative to the purchasing power of money at a fixed date (1972/73), thereby avoiding the problems of forecasting future rates of inflation.

Risk and uncertainty could not be incorporated explicitly in the analyses, for lack of information. However sensitivity testing of the results was often carried out in an attempt to define the range over which the particular result would hold. The specific aspects of risk and uncertainty in relation to the discount rate are discussed in Appendix 3.1 (page A 1).

Externalities have also been omitted from the basic analyses. Externalities such as water production and quality, landscape aesthetics, recreational use, and preservation values could not be incorporated for lack of data. While none of these aspects seemed likely to be of major significance in relation to the regional comparisons of the land uses involved in this study, the results of the analyses must be interpreted with some caution in the light of their omission. One further externality which also warrants caution in this regard is the possible loss of utility suffered on the part of an individual farmer in shifting to an alternative form of land use. This aspect will be developed in more detail in a later chapter.

NET SOCIAL BENEFIT

Net social benefit is defined as the sum of consumers' and producers' surpluses, appropriately discounted. In this study, however, the change in consumers' surplus associated with any change of scale of production or of land use was assumed to be negligible, and hence net social benefit was evaluated solely in terms of producers' surplus. Such an assumption is not unreasonable because the changes in price induced by changes in the scale of production or of land use seemed likely to be very small. This point is developed further at appropriate points later in this thesis.

As far as possible costs have been measured in terms of the opportunity costs involved i.e. the alternative foregone. This is particularly relevant in the case of farm labour. The accounts of the family farm typically do not record payments for the labour of the farmer or his family. Farm labour was therefore valued at the earnings which could have been attained in the next best alternative form of employment. This may admittedly be an underestimate of the true transfer earnings because such market earnings may not adequately reflect the utility the particular farmer gains from his occupation. The valuation of land was also based on opportunity costs rather than market records and will be developed further later in the thesis.

Subsidies and Taxes

Subsidies and taxes generally represent transfer payments from public to private sector, or vice versa, and in principle should not be treated as revenues or costs in a social cost-benefit analysis (Ferguson, 1974). Thus taxes on income, whether accruing to labour, capital or any other resource, should not be netted out from the income. Production subsidies should similarly be deducted from the prices of subsidized outputs but should not be deducted from the prices of subsidized inputs. Import tariffs and export subsidies should be treated the same way.

However, this is an area in which some compromise of the underlying principle is sometimes justified. While import tariffs and export subsidies were removed in estimating the revenues from various final products, the situation was not so simple with regard to inputs. The prices for purchased inputs such as fertilizers, machinery and equipment in Australia are generally higher than would be the case because of a wide-ranging and complex system of protection. This system includes tariffs, import quotas, local manufacturing requirements, tacit agreements between trading partners and so on. Lloyd (1973) argued that, in general, the tariffs incorporated in the prices of agricultural inputs should not be removed because they are offset by other equally wide-ranging and diverse forms of assistance such as production credit, subsidized irrigation, freight subsidies, disease control assistance, agricultural extension and research.

This mutually cancelling effect is supported by Bureau of Agricultural Economics (1975 a & b) data. The effective rate of protection for the beef cattle industry in New South Wales was only 1.2 percent. Similarly, if one ignores consumer transfers resulting from protection of markets for dairy products, the effective rate of protection for dairying in New South Wales was less than 3 percent. The situation with respect to forestry is not so clear and warrants further investigation. Nevertheless, a qualitative review of forestry seemed to indicate that this assumption was reasonable.

In this analysis, it was decided to trace and adjust for as many subsidies and tariffs as possible in order to arrive at a close approximation of the net social benefits accruing to each land use. This tended to disadvantage forestry since it was impossible to eliminate the impact of tariffs on the prices of purchased inputs.

Valuation Formula

In the case of dairying and beef grazing, net **present value** (PV) was evaluated for a complete farm unit and the average value per hectare was then derived by dividing by the area of the farm:-

$$PV = \left\{ \left(\sum_j \sum_t p_j y_{jt} - c_t - k_t \right) / (1+i)^t \right\} / h \qquad (3.1)$$

where j denotes the j'th product of n products,

t denotes the year in which benefits and costs occur,

p_j denotes the social price of the j'th product per unit of output,

y_{jt} denotes the yield of the j'th product in year t,

c_t denotes the social value of operating costs incurred in year t in dollars,

k_t denotes the social cost of farm improvements and developments in year t,

h denotes the area of the farm in hectares, and

i denotes the social rate of discount expressed as a decimal.

This formula represents a general model for an existing or new farm in which periodic outlays are incurred on fixed capital improvements and further farm development (sowing of new areas of improved pasture, clearing more land and so on).

For an infinite time period and assuming constant annual net social benefits, equation (3.1) reduces to:-

$$PV = \left\{(\Sigma p_j y_j - c - k)/i\right\} /h \qquad (3.2)$$

where $(\Sigma p_j y_j - c - k)$ represents the constant annual stream of net social benefits.

The net present value per hectare for the plantation alternatives was evaluated by means of the Faustman formula:-

$$PV = \left\{\sum_{jt}\sum_{j} p_j y_{jt} (1+i)^{r-t} - \sum_{t} c_t (1+i)^{r-t} - a((1+i)^r - 1)/i\right\} / ((1+i)^r - 1) \qquad (3.3)$$

where j denotes the j'th product of n products,

t denotes the year in period r years since commencement of the plantation,

r denotes the rotation length in years,

p_j denotes the social price of the j'th product in dollars per m^3 log volume,

y_{jt} denotes the yield of the j'th product in the t'th year in m^3 log volume per hectare,

c_t denotes the social cost incurred in the t'th year in dollars per hectare, and

a denotes the annual cost of maintaining and protecting the plantations in dollars per hectare.

It was assumed in this formula that all benefits and costs can be effectively isolated for an average hectare of plantation. This is not unrealistic with respect to most of the benefits and costs to be evaluated in this investigation, but a major difficulty is encountered in the allocation of administrative and other overhead costs since these are joint costs and therefore extremely difficult to link directly to specific operations and activities. The procedure adopted consisted of allocating these costs on a pro rata basis according to the level of field costs incurred on each operation. There is a tendency in this approach to provide a rather conservative estimate of net present value per hectare since the high initial investment tends to attract a disproportionately larger amount of overhead than in fact is actually incurred.

Shadow Prices

Imperfections in the markets for inputs and outputs probably represent the main source of distortion to prices but the necessity to adjust observed prices depends on the degree of divergence between these prices and the equivalent non-distorted market prices. Where monopolistic and monopsonistic elements exist in the markets for the commodities produced or purchased, these distortions can be best eliminated by imputing the social value from the price of some final (or intermediate) stage good derived from the commodity and which has been established in a market which is freely competitive (Ferguson, 1974). The procedure used in this study is termed residual value pricing and involved deducting the marginal social costs required to process and distribute the derived-demand commodity into the final or intermediate stage good on which the residual value is based. The main weakness of the approach is the difficulty of obtaining reliable marginal cost data.

Outputs

The most appropriate starting point for deriving the residual value of outputs is generally the world market price for the good consumed, since price determination in international trade often closely approximates the freely competitive model. Thus for a land use in which the output is an import competing good, the import replacement price was used as a starting point; for a land use involving an export oriented good, the free-on-board (f.o.b.) export price was used.

The derivation of shadow prices for forestry and agriculture are described in detail in Chapters 5, 6 and 7.

Inputs

Labour

Statistics on employment (Commonwealth Bureau of Census and Statistics, 1973b; Commonwealth Employment Office, Bega, unpublished data) indicate the unemployment rate in the Region to be much the same as the national average which until recently rarely exceeded 2 percent over the past 30 years. However it is well in excess of the rate of unfilled vacancies even during years of strong demand for labour. This is considered to be more a problem of finding employment for temporarily immobilized sections of the workforce such as school-leavers rather than one of hardcore unemployment.

In view of the relatively low unemployment rate in the Region it seemed reasonable to assume that labour is fully employed; therefore the costs for labour recorded in the financial accounts of the firms carrying on the three land uses approximate to its social value. The main valuation problem arises in relation to the farming alternatives where the owner-operator family farm was adopted as the basic unit of production. Since the cost of labour contributed by the farmer and his family does not enter into the financial accounts it was necessary to impute a value equal to its social cost. The price of the family's labour in the dairying alternative was assumed to be equivalent to the minimum wage for a general farm hand as set down in the Dairy Employees (State) Award for New South Wales and in the case of the owner-operator, the minimum wage for a farm control hand. For beef grazing, the costs adopted for labour in the Australian Beef Cattle Industry Survey 1968-69 to 1970-71 for the coastal region of New South Wales (McCumstie, 1973) were used but updated for price increases as required.

Capital

Income cannot be generated by a particular land use unless capital is combined with land and labour. But capital also has a social cost in terms of the benefits foregone in alternative investments. Thus capital includes not only its initial value at the time when it is created but also the benefits foregone, both present and future, in the next best alternative investment. The benefits generated by a particular land use must therefore be sufficient to offset the initial investment as well as its opportunity cost.

This leads into the long-standing debate over the social cost of capital since it has important implications for public investment projects particularly with respect to the choice of the social rate of discount for discounting social benefits and costs attributable to long-term projects such as forestry. The rate of discount and related parameters to use in evaluation of land-use projects has recently been investigated and the published results of this research (Ferguson and Reilly, 1975a) are provided in Appendix 3.1 (page A1). Although it is not proposed to report these results in detail, some reference to the main findings is necessary since this represents one of the most significant features in the analytical framework adopted in this study.

It was considered that a Pareto optimal solution letting both public and private sectors of the capital market adjust to a common rate of interest, did not seem to be feasible because of the existence of market imperfections. Thus the use of the social rate of time preference as the discount rate and of a separate shadow price (or prices) for scarce capital was preferred rather than rely on some synthetic discount rate which lies between the social rate of time preference and the marginal rate of return on private investment.

1. Social Rate of Discount

A value of 5 percent was chosen as the "most likely" social rate of time preference. This approximated the median value for the "real" rate of interest payable on Australian securities sold in overseas markets. No great precision could be imputed to this figure but it does seem likely that the true value lies between 4 and 6 percent. Thus a lower and upper bound of 4 and 6 percent respectively were also used in the analysis to test the sensitivity of each land use to changes in this parameter.

2. Shadow Prices

The following categories of funds are used by the Forestry Commission of New South Wales to finance its operations:-

(i) Consolidated revenue funds

(ii) Trust funds

(iii) Loan funds.

These categories admittedly reflect historical accounting and budgeting methods rather than meaningful economic identities. However they do form the basis for costing, budgeting, and resource allocation within the New South Wales Public Service and therefore since it is likely that they will remain so, it seems appropriate to apply different shadow prices to them.

(a) Consolidated revenue funds

These funds are raised from taxes and from revenues of public enterprises. The shadow price of these funds was estimated to be one (see Appendix 3.1, page A.6)

(b) Trust funds

These are generally derived from the revenues of the public enterprise concerned and are funds allocated to some specific use, generally under the control of the public enterprise concerned. Under Section 13 of the Forestry Act of New South Wales, 1961, for example, one-half of the gross proceeds of the Forestry Commission is set aside in a Special Deposit Account for use in afforestation and other specified purposes under the control of the Commission. These funds are clearly related to public investment and therefore, as for consolidated revenue funds, have a shadow price of one.

(c) Loan funds

Loan funds are raised either from the sale of government securities, mainly within Australia or from the surplus on the current account of the Australian government (Mathews, 1971). A conservative approach was adopted to ensure the efficient use of loan funds by assuming that these funds have been diverted from private investment. The shadow price calculated at 5 percent social rate of discount was 2.73, based on a marginal tax rate on corporate income of 0.475, a marginal propensity to save of 0.19, and a marginal rate of return before tax on private investment of 0.12. Thus each dollar of loan funds used will be priced at $2.73 in calculating net social benefit.

Using the same values for the marginal rate of tax on corporate income, the marginal propensity to save, and the marginal rate of return before tax on private investment, the shadow prices for loan funds at 4 and 6 percent social rates of discount were estimated to be 3.62 and 2.19 respectively.

AN OVERVIEW

The comparison of the three land use alternatives is based on the present value of net social benefits (or costs) per hectare accruing to each land use. The present value criteria were derived by subtracting the discounted value of social costs from the discounted value of social benefits, using the most likely values for the benefits and costs.

Only primary benefits and costs were considered and they were discounted using an estimate of the social discount rate. The land use yielding the highest present value per hectare was considered to be most efficient and would provide the best alternative for public investment. The analysis was carried out in an unconstrained situation, but a combination of a sensitivity/ contingency analysis was undertaken to test the impact of changes in key decision variables. This involved estimating upper and lower bounds for these variables and substituting the values so derived for the most likely values used in the main investigation.

CHAPTER 4

PRODUCTION LEVELS AND COSTS

Development of complete production functions for each land use was not possible in the absence of detailed input-output data. However, sufficient information was available to enable specification of two or more alternative management strategies for each land use and estimation of the input-output data for these strategies.

Residual imputation (Parish and Dillon, 1955) was used to calculate the comparative values of net social benefit for the various strategies and forms of land use, assuming land to be the sole scarce resource. Factor and product prices were assumed to remain constant, regardless of the level of productivity in the strategy concerned or of the form of land use. While these assumptions may not generally hold, they seem appropriate for an initial comparison of alternative land covering many forms, since the potential shifts in production are small in relation to overall levels in the Region.

RADIATA PINE PLANTATIONS

Although the Forestry Commission is assumed to be the agent responsible for plantation management decisions, it could implement a plantation program either by purchase of the land, or by encouraging the development of farmer co-operatives, or by aid to individual farmers. In the latter two cases, the use of a strategy which integrated well with other farm activities and which provided early and more or less continuous cash returns might be critical (for example, Borough and Reilly, 1976, and Ferguson and Reilly, 1977).

Hence three major strategies were defined to encompass a wide range of possibilities in terms of implementation and markets. For each of these strategies, a limited number of alternatives in terms of rotation length and/or thinning regime were also examined. It was assumed that farmland would be converted exclusively to radiata pine.

Description of Strategies

Forestry A.

The aim of this strategy is not to carry out any thinning but to clearfall the plantation as early as possible for pulpwood production. Two rotations, 15 and 20 years, were considered.

Forestry B.

The joint production of pulpwood and sawlogs is the primary aim in this strategy. All trees are ground-pruned when the plantation reaches a mean height of 8 metres. First thinning involved mechanically removing every third row and selectively removing trees unlikely to yield a sawlog at a later thinning from between rows. Thinning was deliberately delayed until age 15 to ensure satisfactory branch and stem development for framing timber production. Subsequent thinnings were from below to 23 square metres per hectare (m^2/ha) residual basal area and were carried out at 5-yearly intervals up to and including age 25 years. Three rotations were evaluated - 30, 35 and 40 years.

Forestry C.

The purpose of this strategy was to increase early yields of sawlogs by pre-commercially thinning the plantation to approximately 600 to 650 trees per hectare at age 6 to 7 years, depending on site index. This residual stocking figure was about mid-way between the range of stockings evaluated by Forrest (1974) in his study of the economics of thinning radiata pine in New South Wales plantations. To maintain and ensure suitable wood quality for both the production of framing timber and clear grades, the best 300 trees per hectare were to be high-pruned when the dominant height (i.e. the average height of the tallest 40 trees per hectare) of the plantation reached three times the pruning height which at second pruning would be 4.3 metres (m) and at the third and final pruning, 6 metres. Production thinnings were to be from below and selective. Again, as in Forestry B, they were carried out at 5-yearly intervals up to and including age 25 with stocking reduced to 23 m^2/ha. Rotations of 30, 35 and 40 years were evaluated.

The initial stocking adopted in each of these strategies was almost 1,600 trees per hectare, or about 3.0 m x 2.2 m spacing.

Production Levels for Radiata Pine Plantations

Yields were estimated by means of a growth and yield simulation model, CSIM, developed for radiata pine plantations by the Forestry Commission of New South Wales using growth data principally from thinning trials supplemented, when applicable, by data from continuous forest inventory plots (Cosco, 1971). The model incorporates a number of regression functions which predict:-

(i) basal area growth in terms of age, site and relative density (defined as the ratio of existing basal area to total potential basal area),

(ii) mean dominant height in terms of age, and

(iii) the diameter breast height over bark (d.b.h.) of zero growth so that the growth of a particular period can be distributed over diameter classes above this point by appropriate iterative procedures.

Thinning from below is simulated by two thinning functions. The first applies to first thinning only and the other to later thinnings. They are used to predict the percentage of each diameter class to be removed in terms of age, percentage basal area to be removed, position of diameter class in relation to the first size class, the number of stems in the class, and in the case of the first thinning function, the percentage of the stand smaller than and inclusive of the subject class.

Comparisons of yields were also made between CSIM and other yield models for radiata pine including PREDICT, a simulation model developed by APM Forests Pty. Ltd. (Hall, 1974) and the South Australian Yield

Tables (Lewis et al., 1976). Using the stand data reported in Hall's (1974) study, it was found that the yields simulated by CSIM were comparable with those from the South Australian Yield Tables but proved to be consistently higher than PREDICT. The reason for the latter difference could not be identified but more credence must be given to the South Australian results because they are based on data covering a wide range of ages and sites. CSIM was preferred to the South Australian Yield Tables because of the wider range of thinning strategies capable of being simulated by it, including Forestry C (Forrest, 1974).

Since the CSIM model was based on growth data from New South Wales plantations, including plantations located within the Region at Nalbaugh and Bondi State Forests, it was also considered more suitable for predicting yields from plantations likely to be established on the Region's farmlands.

Its suitability was tested by comparing basal area production for a simulated plantation with that for comparably-thinned plantations of approximately the same index at Bondi State Forest. The data do not lend themselves to statistical analysis but the results suggest that the simulation model may under-estimate yield. Hence the results of analyses based on these estimates are likely to be conservative.

The site indices adopted for the simulated plantations were based on the findings outlined earlier in Chapter 2. These fell into two broad groupings - those averaging site index 21 m to 24 m and site index 25 m to 27 m. However, because intensive establishment techniques would be used, some improvement in site index should occur and the average site index of these two groupings was increased to 24 m and 27 m respectively for simulation purposes.

TABLE 4.1

Basic stand data for simulating yields from adopted supply alternatives for radiata pine plantations

	Item	Forestry A & B		Forestry C	
		SI 24	SI 27	SI 24	SI 27
(1)	Age (years)	10	10	15	10
(2)	Dominant Height (m)	12.8	14.3	18.3	14.3
(3)	Trees per ha	1,552	1,576	633	618
(4)	Diameter (d.b.h.) distribution (trees per ha)				
	Less than 2.5 cm	10	10		
	2.5 - 5.0 cm	34	30		
	5.0 - 7.5 cm	108	88		
	7.5 - 10.0 cm	213	188		
	10.0 - 12.5 cm	341	326		
	12.5 - 15.0 cm	425	435	7	119
	15.0 - 17.5 cm	297	331	20	331
	17.5 - 20.0 cm	99	133	67	133
	20.0 - 22.5 cm	20	30	109	30
	22.5 - 25.0 cm	5	5	161	5
	25.0 - 27.5 cm			146	
	27.5 - 30.0 cm			74	
	30.0 - 32.5 cm			37	
	32.5 - 35.0 cm			12	

Simulations were based on the stand data presented in Table 4.1. Hall's (1974) data were adopted for Forestry A and B because of the similarity of the Region to the area where the plantations from which the data originated, are located. Hall's site index 12.8 m and 14.3 m plantations (based on age 10) corresponded with the site index 24 and 27 plantations postulated.

However it was necessary to turn to other sources of stand data for Forestry C since Hall (1974) did not report any data which reflected pre-commercial thinning in his study. Actual data from pre-commercial thinning trials in the Tumut Forestry District of New South Wales (Forestry Commission of New South Wales, unpublished data) were used for site index 24 plantations while for site index 27 stands, yields were simply based on the largest 618 trees per hectare for the 10-year old plantations used for Forestry A and B.

In all strategies, the yields to 7.5 cm small-end-diameter under bark (s.e.d.) were reduced by 10 percent to compensate for losses caused by felling and snigging. This adjustment was applied equally to both pulpwood and sawlog volumes, and was considered conservative for Forestry B and C strategies since most of the damage normally occurs in the top section of the trees which is usually of pulpwood size only.

With respect to Forestry A and B strategies, it was decided to disregard the effect of pruning on growth altogether since ground pruning is widely practiced in New South Wales and therefore at least some of its effect, if any (see for example, Shepherd, (1967) and McKinnell, (1974)), would already be incorporated in the growth equations in the CSIM model.

TABLE 4.2

Simulated yields for radiata pine plantation alternatives

Supply alternative	Product	Volume per hectare (m^3) at age 15	20	25	30*	35*	40*
FORESTRY A							
SI 24	P	237(C)	396(C)	565(C)			
SI 27	P	284(C)	475(C)	672(C)			
FORESTRY B							
SI 24	P	93(T)	54(T)	13(T)	15(C)	14(C)	13(C)
	S	-	15(T)	83(T)	306(C)	416(C)	513(C)
SI 27	P	97(T)	81(T)	13(T)	15(C)	14(C)	13(C)
	S	-	31(T)	95(T)	346(C)	474(C)	591(C)
FORESTRY C							
SI 24	P	-	19(T)	3(T)	5(C)	4(C)	4(C)
	S	-	119(T)	81(T)	315(C)	420(C)	517(C)
SI 27	P	-	20(T)	-	-	-	-
	S	-	156(T)	99(T)	366(C)	500(C)	622(C)

Notations:-

Product : P = pulp; S = sawlog

Thinning : T = thinning; C = clearfelling

* denotes alternative rotation lengths

Under normal field conditions, some loss in yield seemed likely to occur under the Forestry C strategy, the main effect being experienced in plantations of lower site quality. The site index of the nominal site index 24 stand was therefore reduced by 1.2 m in the simulation to allow for this effect. No such adjustment was made for the site index 27 stand.

Sawlog volumes were confined to trees 25 cm d.b.h. and over and less than 15 cm s.e.d. while the remaining volume to 7.5 cm s.e.d. and for trees less than 25 cm d.b.h. was classified as pulpwood. Sawlog yields have also been sorted into five d.b.h. classes as follows: 25 to 30 cm; 30 to 35 cm; 35 to 40 cm; 40 to 50 cm; and 50 cm plus.

Detailed yield tables simulated for each strategy are given in Appendix 4.1 page A10. The yields are summarized in Table 4.2. They have not been reduced by the ten percent logging losses referred to earlier and therefore represent gross yields per hectare.

Plantation Costs

Costs for field operations (field costs) were based on relatively large-scale plantation projects located in the Region or in comparable areas elsewhere. These costs were collected from three organisations - the

Forestry Commission of New South Wales, APM Forests Pty. Ltd. and Kapunda Development Co.Pty. Ltd. - all of which employ modern accounting systems for cost control and recording purposes.

TABLE 4.3

Estimated field costs for radiata pine plantation strategies, Forestry A, B and C

Year	Operation	Cost per hectare ($)		
		Forestry A	Forestry B	Forestry C
0	Establishment	145.2	145.2	145.2
1	Weed & coppice control	6.0	6.0	6.0
7	Pre-commercial thinning	-	-	60.5
	Ground prune to 2.5 m	-	71.5	46.2
9-10	Second prune to 4.3 m	-	-	25.3
13-14	Final prune to 6.0 m	-	-	31.9
R, 2R etc.	Re-establishment at the end of each rotation (R)	132.0	132.0	132.0
	Annual recurring costs	7.0	7.0	7.0

Field costs include all direct and indirect labour, materials and plant hire costs incurred on field operations. They do not include salaries paid to professional, supervisory and administrative staff and related costs but they do include field overheads such as wet weather work, plant transfers, training costs, payroll tax, workers' compensation and other miscellaneous expenditure.

The estimated field costs are summarized in Table 4.3. They have been subdivided into two further categories - those of a non-recurring nature usually involving major expenditure such as site preparation, planting, fertilization, pruning and roading, and those incurred regularly each year such as maintenance of buildings, roads and other capital improvements, protection from disease, insects and fire, weed and sucker tending, research and surveys.

Further details of field costs are given in Appendix 4.2 (page A 11). It should be noted that no attempt was made to eliminate the cost of tariffs from the costs of any purchased inputs but the cost of fertilizer was increased by $11.81 per tonne to eliminate the bounty then current on superphosphate.

Administrative costs represent another group of costs and include all staff salaries, including superannuation, payroll tax, and travelling expenses, as well as the more general administrative costs incurred on stationery, office rentals, office equipment and furniture, postage, telephone, electricity and office maintenance, irrespective of whether incurred by field officers and their staff or by the central office. Since it was not possible to attach these costs to any specific year or operation, they were allocated on a pro rata basis to field costs. The pro rata rate was estimated to be 50 percent of field expenditure. This estimate was derived by relating total expenditure on administration plus group votes and superannuation reported by the Forestry Commission of New South Wales (1974) in its Annual Report to that on all other expenditure but excluding debt charges and Division of Wood Technology expenditure. The derived value of 65 percent was reduced to 50 percent to allow for some over-estimation due to the exclusion of the latter two items and for the Commission's activities of a public service nature and which are unrelated to its production operations.

Social opportunity costs or shadow-prices imputed for the various sources of funds employed in the plantations constituted the third major class of costs and have been described earlier in Chapter 3. The shadow price for Loan funds was estimated to be $2.73 based on a 5 percent social rate of discount, and $1 for Trust and Consolidated Revenue funds. Field and administrative costs were assumed to be financed in fundamentally the same way as that adopted by the Forestry Commission of New South Wales. All administrative and some marketing costs are funded from Consolidated Revenue; all surveys, maintenance of capital improvements (roads, buildings, etc.), protection, research and remaining marketing costs are financed out of Trust funds; and all reforestation (plantation establishment and other non-recurring activities), new construction (buildings, roads, etc.) and all overheads are funded by means of Loan funds. This differs from the Forestry Commission's pattern only by incorporating all field overheads under Loan rather than both Loan and Trust funds.

A dissection of costs by operation and by source of funds is provided in Appendices 4.3 and 4.4 for Forestry A and B, and for Forestry C respectively. The social opportunity costs of Loan funds for the three social rates of discount (4, 5 and 6 percent) are also shown, being required for subsequent tests of the sensitivity of each strategy to changes in this parameter. The shadow prices were estimated to be \$3.62 and \$2.19 respectively for 4 and 6 percent.

DAIRYING

The technological efficiency and scale of forestry operations implied in the previous section are those expected of a reasonably efficient operation. Clearly, comparisons of forestry with other forms of land use need to be on a similar basis for the other forms of land use. Thus the production levels and costs for dairying (and for beef grazing in the next section) have been estimated for an owner-operator of reasonable efficiency who operates at a scale appropriate to the present market conditions and trends. These data are therefore not representative of much of the current farming, which is typically of a smaller scale and less advanced technology.

Description of Strategies

Two strategies were defined: one, termed Dairying A, representing a large fully developed farm of 300 ha, completely sown to improved pasture; the other, Dairying B, an average farm based on a sample of farms in the Region. The latter was included solely to enable comparisons of Dairying A with existing conditions. Production levels and costs for Dairying A were based on whole-milk production only whereas both cream and whole-milk were produced by Dairying B.

Production Levels for Dairying

The production level for Dairying A was estimated from a production function of the Cobb-Douglas type developed by Ryan (1975) using data from the Australian Dairy Industry Survey from 1967-68 to 1969-70 (Bureau of Agricultural Economics, unpublished data). The function is structured in such a way that estimates of milk production per cow could be determined for each of the five regions covered by the Survey in New South Wales, including the Lower South Coast.

TABLE 4.4

Details of farm and herd size, land use pattern, estimated milk production and assumed inputs for Dairying A and Dairying B

Item	Dairying A	Dairying B
Land Use (ha):-		
Improved pasture	280	74
Native pasture	-	42
Cropped	20	11
Unimproved	-	23
Wasteland	-	3
Total Area	300	153
Herd Size (in cow equivalents):-		
Milked	200	73
Total	300	114
Input Requirements:-		
Labour (adult male equivalents):		
- Owner-operator	1	1
- Family	-	0.7
- Hired	2	-
Total land value ($1967)	50,000	Not required
Capital value (excluding land and cows in $1968-69)	30,000	"
Cereals fed (m^3)	230	"
Hay and silage (tonnes)	630	"
Milk Production (litres/annum):-		
Per cow	3,100	2,392
Total farm	620,000	173,000
Livestock Sales (No.):-		
Cull cows	42	Not required
Calves	140	"

Independent variables for the function included dummy variables for year of observation, region, herd-recording x region, herd-recording x region x artificial breeding and continuous variables consisting of cost of dairy labour ($), number of cows, land value (in 1967 prices), capital excluding land and cows ($), improved pasture (ha), irrigated land (ha), cereals fed (m^3), hay and silage fed (tonnes), fruit and vegetables fed (m^3), milk products fed (kl) and feed and concentrates fed (kg).

The values adopted for land use, dairy herd size and inputs for substitution in the estimating equation for Dairying A are shown in Table 4.4. Land, labour and capital were estimated by means of cross-sectional analysis of inputs by dairy herd size using Regional data from the Australian Dairy Industry Survey. The quantity of cereals fed was based on estimates supplied by the Department of Agriculture, Bega while data reported by Rance and Gordon (undated) were used to calculate hay and silage consumed.

The yield per cow for Dairying A was estimated to be 2,932 litres per annum, using Ryan's (1975) equation. This was increased to 3,100 litres per annum for this study to take into account more normal climatic conditions than those experienced at the time of the survey and to include productivity increases since that time.

Additional returns are also earned from livestock sales either from cull cows or calves from the dairy enterprise or from beef cattle or pigs. Livestock sales from Dairying A were based on the same assumptions used by the Bureau of Agricultural Economics (1972) for their "dairying only" activity as follows:-

(a) an annual mortality of 3 percent per year;

(b) a heifer replacement rate of 24 percent per year including mortality replacement; and

(c) calving rates of 87 percent for established milkers and 79 percent for heifers.

Therefore the number of livestock sold in this strategy was estimated to be 42 cull cows and approximately 140 calves. No other livestock enterprise was considered.

All values shown in Table 4.4 for Dairying B are farm averages for the Lower South Coast Region originating direct from the Dairy Industry Survey.

Livestock sales for Dairying B were based on average returns of $1,783 per farm from the Dairy Industry Survey. These returns were simply updated to 1972/73 values by means of the estimated average increase of 22.1 percent in average export values for beef, veal and for pork based on data published every three months in the Quarterly Review of Agricultural Economics. The adjusted value of these returns was $2,177.

Production Costs

The annual costs of production adopted for Dairying A and B are shown in Table 4.5.

TABLE 4.5

Estimated social cost of production for dairying strategies, Dairying A and B, in 1972/73 dollars

Item	Dairying A	Dairying B
1. Labour:-		
Owner-operator	3,905	3,905
Hired	6,155	-
Family	-	1,958
2. Materials:-		
Fodder	11,102	5,337
Fertilizer (excludes bounty)	2,720	
Other	4,640	
3. Services and contractors	1,900	1,000
4. Capital replacement	3,380	1,410
5. Return to management	1,200	588
Total Unadjusted Costs	35,002	14,198
Plus superphosphate bounty	945	213
Less tariff on tradeable inputs:-		
Materials	1,676	304
Capital items	649	271
Total Adjusted Costs	33,622	13,836

Costs for labour were based on the physical inputs shown in Table 4.4 and on minimum wage rates under the Dairy Employees (State) Award for New South Wales (Department of Labour and Industry, New South Wales, 1973). A weekly wage rate of $53.80 for a farm hand was adopted for hired and family (other than the owner-operator) labour[1] and $75.10 for the owner-operator based on the Award rate for a farm control hand.

Labour additional to the owner-operator in Dairying A was assumed to be hired and not drawn from family labour. A surcharge of 10 percent was added to hired labour to allow for workers' compensation and payroll tax but no such adjustment was made to the owner-operator's or the family's labour cost on the assumption that this was equal in value to the utility derived by the farmer and his family as a result of their way of life and therefore could be disregarded.

The fodder cost for Dairying A was based on a daily field requirement of 2.27 kg of wheat per cow at a delivered cost of $67/tonne. The subsidized cost for superphosphate includes a delivered price of $24/tonne including freight and handling. A cost of $10/tonne was adopted for aerial top dressing. Application rates per annum assumed were 0.25 tonne/ha for improved pasture and 0.5 tonne/ha for cropped land.

[1] Labour inputs in dairying were costed at existing rates and differed somewhat from those used in beef grazing or forestry. This treatment reflects an earlier assumption that the labour market was reasonably competitive enabling existing rates to be taken as representative of marginal social costs. The small differentials in rates between these sectors are assumed to be equilibrium differentials, due to differences in skills or, more likely, to differences in non-monetary aspects of employment between these sectors.

The cost of "other materials" and "services and contractors" for Dairying A were estimates from a cross-sectional analysis of costs by herd-size from the Dairy Industry Survey updated to 1972/73 prices or from data supplied by the Department of Agriculture, Bega. Details of the items making up these costs are presented in Appendix 4.5 (page A 19).

The cost of replacing fixed improvements (assumed to equal depreciation) was also estimated from the same cross-sectional analysis of costs but in addition to adjustments for inflation, a further adjustment was made for the full costs of a refrigerated vat and an all-weather access road.

All Dairying B costs other than labour and the return to management were taken direct from the Dairy Industry Survey averages for the Region. Adjustments for inflation to the costs of materials was based on the Index of Prices Paid by Farmers for Equipment and Supplies published in the Quarterly Review of Agricultural Economics, while adjustment to the cost of services was based on the Index of Prices for Services and Overheads also published in the same journal.

Adjustments to Costs

It was not possible to determine the effective rate of protection for radiata pine plantations primarily because of the difficulty of separating out individual items comprising the costs which have been adopted. However, in the case of dairying and beef grazing, recent studies of the effective level of protection in the dairying and beef cattle industries suggested that some adjustment should also be made for the effect of the tariff on the cost of tradeable inputs. The neglect of this adjustment in the case of forestry tends to place it at something of a disadvantage, although the effect is probably not of major consequence.

Therefore in addition to adding the bounty on superphosphate of $11.81 to total costs, deductions have also been made for the cost of the tariff on tradeable inputs. For Dairying A, tariff rates of 15.1% and 19.2% were adopted for wheat fodder and capital costs respectively. The tariff on wheat is the actual tariff rate operating in 1972/73 (Bureau of Agricultural Economics, 1975a) and that for capital items was estimated by relating the cost of the tariff calculated by the Bureau of Agricultural Economics (op. cit.) to the total cost of these items for New South Wales dairying during the period 1971/72 and 1973/74. The average rates of 5.7 percent and 19.2 percent adopted for materials and capital items respectively for Dairying B were estimated in the same way.

The total values of the subsidy cost and the tariffs, and the adjusted costs are shown in Table 4.5.

BEEF GRAZING

Because beef grazing has been an important land use in the farming areas for only a comparatively short period, some difficulty was encountered in constructing models which were representative of these areas. However, based on data collected in the Region, two strategies were devised, each representing a stable herd situation and of a size which could reasonably be handled by a single owner-operator.

Description of the Strategies

Beef Grazing A

It was assumed that the property was already sown to improved pastures with breeding and production of vealers the main activity.

Beef Grazing B

To cover the range of possible pasture situations, it was assumed in this strategy that the pasture consists solely of native grasses and that it was managed as such in perpetuity. The main activity consisted of breeding and production of vealers, store calves and steers.

Production Levels

Although the Region was included in the Australian Beef Cattle Industry Survey 1968/69 to 1970/71, the number of farms surveyed in the Region was too small to permit separation of Regional data. Thus the estimation of production costs and levels for the two strategies was based partly on average data reported for the whole coastal region of New South Wales in that survey (McCumstie, 1973), on average data reported in 1973/74 for specialist beef-graziers in the high rainfall zone of Australia in the most recent survey (Bureau of Agricultural Economics, 1975b), and on information collected during the land capability survey (see Chapter 2), particularly from the New South Wales Department of Agriculture.

Production levels were determined on the basis of the following assumptions:-

(i) The size of the breeding herd which could be handled by a single owner-operator was 200 cows, based on data collected within the Region itself and on the study by McCarthy et al. (1970).

(ii) The property was located on typical granite hill country and therefore relied principally on dry farming techniques. For Beef Grazing A, the farm area required to support a breeding herd of 200 cows in this type of country was assumed to be 240 ha and for Beef Grazing B, 720 ha.

(iii) The main aim of management was the production of vealers to be sold at 8 to 12 months. If not finished or sold in this time, they were carried through and finished as steers. Cull and cast-for-age cows and unwanted heifers were immediately sold. Calving was assumed to take place predominantly in autumn with cows fed supplementary diets during the winter period.

(iv) Estimates of herd composition were based on the following:-

(a) Percentage calves dropped to cows joined - 80 percent in Beef Grazing A and 75 percent in Beef Grazing B.

(b) Herd mortality - 2 percent per annum.

(c) Number of bulls - 3 percent of cows in the case of Beef Grazing A and 4 percent in Beef Grazing B.

(d) Number of heifers selected as replacements for cull and cast-for-age cows - 20 percent.

(e) Working life of bull - 6 years.

(v) Prime vealers were to be produced from either dairy cross-bred or pure-bred beef calves in Beef Grazing A, but for Beef Grazing B, only pure-bred calves were to be used.

The livestock inventories based on these assumptions are shown in Table 4.6. The number of cattle sold and their liveweights at sale are also presented. Liveweights were based on gains reported by Davies (1972) and on the upper levels of liveweights reported for stock sold from the Region during the period 1972 to 1974 (The Land, various issues).

TABLE 4.6

Estimated livestock inventories and sale of liveweights under stable herd conditions in Beef Grazing A and B

Beef Cattle Alternative	Cattle Type	Number of Livestock Beginning of year	Mortality	Replacements	Sold	Liveweight (kg)
Beef A	Cows	200	4	44	40	500
	Calves	160	3	-	82	250
	Heifers	50	1	50	5	350
	Steers	25	-	25	25	450
Beef B	Cows	200	4	44	40	500
	Calves	150	3	-	47	250
	Heifers	50	1	50	5	350
	Steers	50	1	50	49	450

TABLE 4.7

Annual operating costs for Beef Grazing A and B strategies

Item	Beef Grazing A	Beef Grazing B
A. Labour - Family and Hired	1,163	1,269
B. Materials:		
Fodder	1,730	1,820
Fertilizer for pasture	1,870	2,975
Fuel and oil	495	540
Other materials	2,046	2,232
C. Services:		
Selling expenses	723	741
Freight on livestock	999	927
Rates and taxes	480	1,440
Other services and overheads	777	849
D. Replacement Costs:		
Structural improvements	652	865
Bulls	600	800
Mobile equipment	1,173	1,173
E. Owner-operator's Labour	2,881	2,881
F. Margin for Management	1,060	1,200
TOTAL COSTS	16,649	19,712
G. Adjustments for Subsidies and Tariffs		
Less tariffs	978	1,957
Plus fertilizer subsidy	768	1,151
TOTAL ADJUSTED COSTS	16,439	18,906

Production Costs

Annual operating costs for beef-grazing are shown in Table 4.7 with a detailed presentation of the bases for their estimation given in Appendix 4.6 (page A 20). Again data sources similar to those used for production levels were used. Where costs related to years other than 1972/73, adjustment was carried out by means of the appropriate index of prices paid by farmers, published by the Bureau of Agricultural Economics in its Quarterly Review of Agricultural Economics. Care was taken to avoid double counting particularly when using costs from the Beef Cattle Industry Surveys. For example, the cost of other materials shown in Table 4.7 was estimated by first of all ensuring that the costs of the other categories (fertilizer, fodder, fuel, seed) were completely removed from the survey figure on which it was based. Costs for the use of a telephone and owning a motor vehicle were also eliminated on the grounds that these represented costs which would have been incurred by the farmer irrespective of whether he was in farming or not. However, transfers associated with tax concessions on these two items were included in the cost budget. Labour costs were estimated on a different basis to that for dairying, using the Beef Cattle Survey data. Freight costs were calculated on the assumption that cattle would be sold at Homebush in Sydney but differentials between Management Areas were ignored since they were considered to be insignificant. The margin for management was estimated in the same way as the dairying strategies.

Adjustments to Costs

Adjustments for the effects of protection from tariffs on input costs and for subsidies were based on data used to estimate the effective level of protection to the beef cattle industry in New South Wales (Bureau of Agricultural Economics, 1975b). The actual adjustments are shown in Table 4.7. Tariff rates of 27.1% and 15.7% were adopted for capital items and materials respectively. They were derived by relating the estimated cost of the tariff for 1971/72 in New South Wales on each category to the total cost of each item.

The superphosphate bounty of $11.81 per tonne was the only form of subsidy which could be relatively easily identified and adjusted for. The total adjusted costs shown in Table 4.7 were used for the purposes of sensitivity testing.

CHAPTER 5

SHADOW PRICES FOR PULPWOOD STUMPAGE

The pulpwood market in the Lower South Coast Region can be best characterised as a bilateral monopoly with one consumer, the Daishowa Inc. chip-mill at Eden, and one major producer, the Forestry Commission of New South Wales. Some pulpwood is also purchased from private property and from mill wastes, but this only represents about 10 percent of the annual consumption.

The price of pulpwood stumpage in the agreement between Daishowa Inc. and the New South Wales Government was arrived at by negotiation. The relative bargaining strength of the two parties was probably the most critical determinant of price. It is not clear whether this price is close to the equilibrium price which would be established by the interaction of demand and supply in a perfectly competitive market. Because of the imperfections in this pulpwood market, and because the going price related only to eucalypt pulpwood, not radiata pine, an independent evaluation of the social price of pulpwood stumpage for radiata pine seemed essential. However there are no freely competitive markets for pulpwood stumpage in Australia which would provide estimates of this price directly. A shadow price therefore had to be imputed using the residual value method (Chapman and Meyer, 1947).

The present industry at Edrom is based on the export of wood-chips to Japan. In principle then, the shadow price for pulpwood stumpage should be determined by working back from the price Japanese firms are willing to pay for Australian wood-chips. While this latter price is not determined in a perfectly competitive market, the processes of competition in world trade seem sufficiently well developed to warrant using the going price of wood-chips as a starting point.

However, further development of the industry at Edrom is envisaged. The agreement between Daishowa Inc. and the New South Wales Government requires that the feasibility of a pulp-mill be investigated and reported to the Government. As a general matter of principle both the New South Wales and Australian Governments would probably prefer to see local processing develop rather than export the raw material. Thus the industry may develop further in the future and produce pulp either for domestic consumption or for export. When this occurs, the shadow price of pulpwood stumpage may increase because of the marked economies which local processing offers with respect to freight especially in relation to pulp for domestic consumption.

The timing and nature of this further development cannot be fully explored in this study because of the complexity of the analysis and the social and political problems involved. Nevertheless, from an economic viewpoint, there should be scope for a pulpmill of efficient size to sell its output in the Sydney market by 1995 (Ferguson and Parkes, 1976). This date provides ample time for recent developments in technology especially in the areas of oxygen bleaching and completely enclosed pulping systems (Twitchell and Edwards, 1974, Vanho and Henricsson, 1975), to be incorporated in the mill design and thus overcome any potential problems associated with pollution or water availability.

Thus two sets of shadow prices were evaluated. The first was based on the export price of wood-chips and was applied up to and including 1994/95. The second was based on the domestic price of pulp and was applied in analyses involving sales of pulpwood from 1995/96 onwards. This latter set of prices can be regarded as being based on "import replacement price", because the sale of pulp in Sydney would greatly reduce if not eliminate imports of pulp.

Before evaluating these shadow prices, some general issues relating to treatment of cyclical fluctuations and to the accuracy of the estimates must be reviewed.

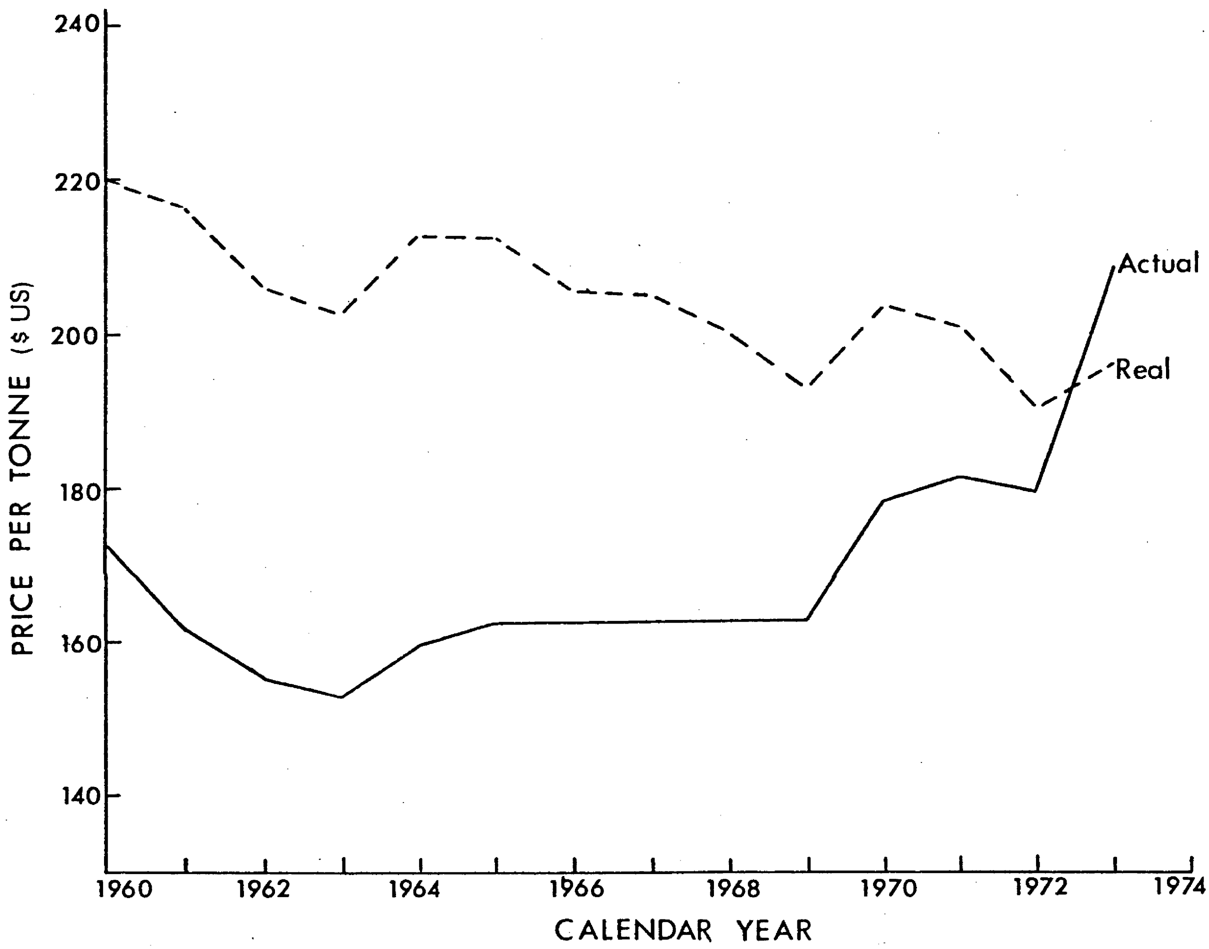

FIGURE 5.1 Trends in actual and real wholesale prices of bleached Kraft pulp in the United States.

(Source: Holt 1974)

DATA

Cyclical Fluctuations

While extended time-series data were not available for the prices of wood-chips and pulp examined in this chapter, cyclical fluctuations were apparent in the real price of bleached kraft pulp in the United States, as Figure 5.1 shows. To smooth out the cyclical fluctuations which might otherwise have made valid comparison with the prices of other products difficult, the average real price over the last complete cycle, from trough to trough, was used to estimate the relevant price.

Actual prices were first expressed in real terms relative to the purchasing power of the dollar in 1972/73, using the consumer price index (CPI) or the wholesale price index (WPI) of the country concerned as a deflator. Real values were then converted to Australian dollars at the ruling official rate of exchange for the year concerned and the average of the resulting values calculated.

While not strictly germane to cyclical fluctuations, the distinction between bone dry tonne (hereafter BDMT) and air dry tonne (ADMT) should be noted because the difference in moisture content is substantial.

Accuracy

The data used to estimate the price and cost components in this chapter were derived from a wide variety of sources, few of which relate directly to the present or future plantation estate in the Lower South Coast Region. In many cases, subjective adjustments had to be made to the published data to reflect conditions in the Region, such adjustments generally being based on discussion with foresters or industry representatives working in the Region. Documentation of the basis and original sources for these estimates is essential if others are to assess its reliability, but documentation alone does not seem sufficient because there is considerable variation in the accuracy of individual components.

The accuracy of the major components has therefore been subjectively assessed and reported using the coefficient of variation as a criterion of accuracy:-

$$CV = \frac{6}{\theta} \qquad (5.1)$$

$$= \frac{\left(B_{\hat{\theta}}^{2} + \mathrm{Var}\,(\hat{\theta})\right)^{\frac{1}{2}}}{\theta} \qquad (5.2)$$

where CV denotes the coefficient of variation,

6 denotes the true standard deviation of the estimate,

θ denotes the true value of the parameter,

$\hat{\theta}$ denotes the expected value of the parameter,

$B_{\hat{\theta}}$ denotes the bias of the estimate, and

Var $(\hat{\theta})$ denotes the estimated variance of the estimate, (i.e. the precision).

Because of the subjective nature of many of the final estimates, they cannot be assumed to be unbiased. Hence the coefficient of variation may include both bias and lack of precision. This ambiguity in the coefficient of variation seems unavoidable since subjective estimates probably involve implicit trade-offs between bias and precision.

The values of the coefficients of variation were based on subjective estimates and may prove inaccurate. Nevertheless they provide a guide to the relative accuracy of the data as gauged at the time the estimates were made. This should at least facilitate the determination of priorities for further work in this area of data collection.

EXPORT PRICE BASIS

The mill-yard price of pulpwood was derived from the export price of wood-chips as follows:-

$$Y_e = (E.B - C)R \qquad (5.3)$$

where Y_e denotes the residual value of radiata pine pulpwood at Edrom mill-yard ($\$/m^3$),

E denotes the estimated price which exports of radiata pine chips would command (\$/BDMT),

B denotes the basic density of radiata pine chips ($BDMT/m^3$),

C denotes the average cost of yarding, chipping, transport by conveyor to chip-pile and from chip-pile to ship, and an allowance for normal profit on investment ($\$/m^3$),

R denotes the proportion by volume of chip material actually recovered from the solid volume.

The estimated values, their estimated coefficients of variation, and the sources on which these estimates were based, are summarized in Table 5.1.

TABLE 5.1

Estimated values, accuracy and sources of data used to calculate mill-yard price (Export Price Basis)

Item	Symbol	Estimate	CV%	Source or basis of estimate
Export price of wood chips at Edrom (f.o.b.)	E	\$27/BDMT	15	N.Z. export price statistics, checked by trend value for U.S. chip exports
Basic density	B	$.42 BDMT/m^3$	5	McKinnell (1970), checked by Maddern Harris (1965) data.
Chipping cost including profit	C	$\$2.95/m^3$	20	Confidential data
Recovery	R	$0.95 m^3/m^3$	10	Bergman (1972), Croon and Frisk (1972) Dillner (1972)
Mill-yard price	Y_e	$\$7.97/m^3$		Equation 5.3

The details of the derivation these values shown in Table 5.1 are discussed in Appendix 5.1 (page A 28). However a brief review of the most critical points seems desirable.

Existing prices paid for Australian wood-chips are confidential and refer to eucalypts, not to radiata pine. However New Zealand also exports wood-chips, predominantly of radiata pine and data were available on the average annual f.o.b. prices for chips since 1969. Because of similarity in ocean haulage distances, freight costs between New Zealand and Japan and Edrom and Japan seemed unlikely to differ significantly, so the average New Zealand price ($28/BDMT) was used in the analysis. A minor downward adjustment was made for the fact that a small proportion of the New Zealand exports consisted of non-coniferous species which would attract a higher value.

The estimated value for the f.o.b. price of wood-chips exported from the United States to Japan for 1972/73 was $A20.0/BDMT. Taking the differences in species, quality of raw material and freight costs into account, the New Zealand estimate seemed sensible.

Chipping costs include the costs associated with storage of pulpwood in the mill-yard, debarking, chipping, stockpiling of chips, transport of chips to chip-piles or to ship, and an allowance for overheads. Each of the major components was based on confidential data which included allowance for a profit margin of unknown magnitude. The components also agreed closely with independent estimates in the literature.

IMPORT REPLACEMENT PRICE BASIS

The mill-yard price of pulpwood was derived from the import replacement price of pulp as follows:-

$$Y_i = (K + F + W - P - T)/S \qquad (5.4)$$

where Y_i denotes the mill-yard price of pulpwood at Edrom ($/m^3),

K denotes the f.o.b. price of bleached kraft pulp in New Zealand ($/ADMT),

F denotes the cost of shipping from New Zealand to Sydney ($/ADMT),

W denotes the cost of wharfage, unloading and transport to papermill in Sydney ($/ADMT),

P denotes the cost of pulping to produce bleached kraft pulp ($/ADMT),

T denotes the cost of transport of pulp from Edrom to Sydney ($/ADMT), and

S denotes the conversion factor for the volume of pulpwood required to yield one ADMT of pulp (m^3/ADMT).

The estimates of these variables, estimates of their coefficients of variation, and the sources on which the estimates were based are shown in Table 5.2.

Details of these estimates are discussed in Appendix 5.2 (page A 36) and only a brief review of the major points is necessary here.

The type of pulp to be produced at Edrom in 1995/96 was assumed to be bleached kraft pulp. Substantial quantities of bleached kraft pulp are imported into Australia to supply the long-fibre bleached component necessary for a number of paper products. In 1972/73, for example, 190,000 tonnes of kraft pulp were imported (Australian Bureau of Statistics, 1974d). The pulping process is also suited to the use of eucalypt and radiata pine pulpwood in mixture, as at the A.P.M. Ltd. mill at Maryvale, Victoria, which would probably be the case for a mill at Edrom. Finally, data on both the prices of imported pulp and on the cost of production for the pulping process were available, which was not the case for other types of pulp.

TABLE 5.2

Estimated values, accuracy and sources of data used to evaluate mill-yard price (Import Replacement Basis)

Item	Symbol	Estimate	CV%	Source or Basis of Estimate
Export price of bleached kraft paper	K	$133.7/ADMT	10	Australian import statistics
Freight costs N.Z. to Sydney	F	$35.9/ADMT	5	General cargo rate, Official statistics
Wharfage cost, Sydney paper mill	W	$11.0/ADMT	15	Personal estimate based on costs reported for similar cargo
Cost of pulping including normal profit	P	$105.80/ADMT	20	Detailed cost analysis revising earlier work by Australian Paper Manufacturers Ltd. (1974)
Transport cost, Edrom-Sydney	T	$11.00/ADMT	15	Personal estimate based on current contract rates
Conversion factor	S	5.4 m^3/ADMT	10	Nelson et al. (1973) and items B and R in Table 5.1
Mill-yard prices	Y_i	$11.81/$m^3$		Equation 5.4

It was assumed that bleached kraft pulp produced at Edrom in 1995/96 would be sold in Sydney. This seemed the most likely development and would yield shadow prices intermediate between the alternatives. Integrated pulp and paper manufacture at Edrom offered likely economies in production costs (Eklund, 1972) but the problems of estimating these costs and of estimating the import replacement price of paper products seemed insurmountable. Export of pulp to Japan offered good market prospects but somewhat lower prices due to the freight charges involved. The problems of estimating the price of pulp were also complex in this case.

The average of the real f.o.b. prices of bleached kraft pulp imported from New Zealand from 1968/69 to 1973/74 was used as a basis for residual value calculations. This pulp is manufactured from radiata pine and is therefore technically identical to the product envisaged from radiata pine pulpwood at Edrom. This price plus the freight costs from New Zealand to Sydney represents the import replacement price and was estimated to be $169-25/ADMT.

As a check on the import replacement value, since price could have been affected by the provisions of the New Zealand-Australia Free Trade Agreement which imposes a penalty tariff if manufacturers do not import New Zealand pulp for a specified proportion of their imports, the f.o.b. price and freight costs for Canadian bleached kraft pulp were estimated. These totalled $170/ADMT.

The average value for New Zealand and Canadian imports of bleached kraft pulp was used in this analysis and was estimated to be equal to $169.6/ADMT.

The other item which involved much data and calculation was the cost of pulping. This cost was based on earlier work by Australian Paper Manufacturers Ltd. (1974) updated in the light of current conditions and data. The costing assumed a pulp-mill would cost $79.2 million in terms of the investment in plant, buildings and interest charges to start up. An allowance for normal profit on investment was made, based on a 15 percent real rate of return on the average (real) capital investment. This was deliberately set higher than the marginal rate of return on private investment in Appendix 3.1 (12 percent) to include an allowance for risk which was not appropriate to the earlier figure.

SHADOW PRICES FOR PULPWOOD STUMPAGE

In order to derive the residual value or shadow price of pulpwood stumpage at the forest, the costs of felling, logging, transport to mill, unloading and administration must be deducted from the appropriate mill-yard price of pulpwood.

Estimates of the harvesting costs were based on the work of Hall (1974) with respect to logging, and De Vries (1973) with respect to haulage. In both cases, adjustments were made to reflect conditions in the Region, and in the case of haulage costs, a more realistic profit allowance for the owner of a logging truck. The final estimates used in subsequent calculations were $4.50/m^3 for logging and administrative costs and $0.035/m^3/km for haulage costs. The coefficients of variation of these estimates were estimated to be .15 and .10 respectively. Details of these estimates are given in Appendix 5.3 (page A51). The resulting shadow prices for pulpwood stumpage from possible future plantations of radiata pine in the various Management Areas are shown in Table 5.3.

TABLE 5.3

Estimated residual values of pulpwood for different Management Areas in the Lower South Coast Region of New South Wales for the periods prior to and subsequent to year 1995.

Management Area	Distance from Edrom (km)	Residual Values ($/cm m)	
		Pre-1995	Post-1995
Bega	100	-	3.81
Bemboka	120	-	3.11
Bondi	68	1.09	4.93
Burragate	60	1.37	5.21
Candelo	95	0.15	3.98
Cobargo	140	-	2.41
Lower Brogo	125	-	2.93
Nungatta	60	1.37	5.21
Pambula	56	1.51	5.35
Wyndham	80	0.67	4.51

The cells without entries are those which would have negative shadow prices up to 1994/95 and would therefore be uneconomic if production commenced prior to that date.

BOUNDS

The coefficients of variation are not an adequate basis for determining bounds because the individual bias components are not known and some of the parameters are not independent. More importantly, however, bounds so calculated would not reflect the uncertainty attached to key assumptions regarding the development of the industry and of the market.

The approach adopted in this study has therefore been based on bounds defined by major changes in the key assumptions. For example, the pulp-mill at Edrom may not eventuate, in which case the shadow prices determined up to 1994/95 would also apply beyond 1994/95. Thus the lower bound for the prices of pulpwood stumpage was based on the pre-1994/95 prices being applied throughout.

The upper bound was based on a pulp-mill starting operation at Edrom in 1984/85 (the earliest feasible date) <u>and</u> on an increase of 0.2 percent per annum in the real price of pulpwood as from 1974/75 for a period of 40 years. This value is subjective but was intended to reflect widespread opinion (Walpole, 1975, Ferguson and Parkes, 1976) that world prices of pulp and paper, and hence of pulpwood, are likely to increase in the future in the face of increasing demand and progressively less attractive forest areas to be opened up for supply.

The values for the upper and lower bound shadow prices are shown in Table 5.4.

TABLE 5.4

Lower and upper bound prices for pulpwood 10, 20, 30 and 40 years after commencement of the plantation project ($ per cubic metre)

Management Area	Lower Bounds - All Periods	Upper Bounds 10 years 1985/86	20 years 1995/96	30 years 2005/6	40 years 2015/16+
Bega	-	3.89	3.97	4.05	4.13
Bemboka	-	3.17	3.24	3.30	3.37
Bondi	1.09	5.03	5.13	5.23	5.34
Burragate	1.37	5.32	5.42	5.53	5.64
Candelo	0.15	4.06	4.14	4.23	4.31
Cobargo	-	2.46	2.51	2.56	2.61
Lower Brogo	-	2.99	3.05	3.11	3.17
Nungatta	1.37	5.32	5.42	5.53	5.64
Pambula	1.51	5.46	5.57	5.68	5.80
Wyndham	0.67	4.60	4.69	4.79	4.89

These bounds are obviously crude but they should suffice to test the sensitivity of the solution to major changes in the pattern of development of the industry.

CHAPTER 6

SHADOW PRICES FOR SAWLOGS

Stumpage prices for sawlogs sold by the Forestry Commission of New South Wales are not determined by the interaction of supply and demand in a perfectly competitive market. The Commission itself possesses a high degree of monopoly power by dint of its control over 55 percent of current annual production in New South Wales, (FORWOOD, 1974a). The sawmilling industry also possesses substantial monopoly power through its main trade association, the Associated Country Sawmillers' Association. Thus the general level of stumpage prices is established by a complex process of bargaining and negotiation between these two bodies, due consideration being given to competition from imported timber. Admittedly this description is over-simplified, since it omits political influences and differences between regions and species, but it highlights the imperfect nature of the market.

Stumpage prices to individual sawmillers operating on Crown forests are established by a royalty appraisal system based on the residual value method of pricing (Chapman and Meyer, 1947). Detailed instructions including standard allowances for various costs are set out in a manual of the Forestry Commission.

The resultant prices, however, may not be appropriate for social cost-benefit analyses since the starting point of the appraisal, the price of sawn timber, is not determined in a freely competitive market situation. The Associated Country Sawmillers Association issue recommended price lists which are essentially calculated on a cost-plus basis and these list prices are closely adhered to in the market most of the time. Thus the price of sawntimber is itself influenced by changes in the general level of stumpage prices. Moreover the price of sawntimber is inflated by tariff protection, which is especially relevant to the Sydney market. Finally, allowances for sawmilling and logging costs in the appraisal system are based on data supplied by the Associated Country Sawmillers Association. The sampling design and standards of cost accounting used in this work, and some of the other allowances in the appraisal system, are open to question in terms of precision and bias.

Because of these imperfections in the existing system of price determination, an independent appraisal of social prices seemed desirable, especially in view of the critical role these prices are likely to play.

The social price of radiata pine sawlogs was therefore estimated using the residual value approach:-

$$P_{ij} = (I + C_{ij} - H_j - M)\ R_i - L_{ij} \qquad (6.1)$$

where P_{ij} denotes the price of radiata pine stumpage for the i'th size class from the j'th location ($/m^3 log volume),

I denotes the import replacement price (i.e. cost excluding the tariff at merchant's yard) of sawntimber ($/m^3 sawn),

C_{ij} denotes the value of woodchips recovered from sawmill waste for logs of size class i from the j'th location ($/m^3 sawn),

H_j denotes the cost of freight and transfer for sawntimber derived from the j'th location from mill to merchant's yard ($/m^3 sawn),

M denotes the cost of sawmilling ($/m^3 sawn)

R_i denotes the proportion of sawn timber recovered from sawlogs of the i'th size class (m^3 sawn per m^3 log volume), and

L_{ij} denotes the cost of logging of sawlogs of the i'th size class at the j'th location to the sawmill ($/m^3 log volume).

TABLE 6.1

Estimated values, accuracy and sources of data used to determine the various price and cost components comprising the import replacement cost of radiata pine sawntimber in Sydney

Item	Estimated Value	Coefficient of Variation	Source or Basis of Estimate
1. Wholesale price of Construction grade framing at United States Sawmill	\$US55.25/m^3	5%	Trend analysis based on monthly quotations by United States Department of Commerce in its Survey of Current Business
2. Cost of packaging, United States	\$US1.80/m^3	10%	Host (1969) adjusted to 1972/73 U.S. values using the U.S. Wholesale Price Index All Commodities
3. Cost of freight, transfer and wharfage, United States	\$US3.00/m^3	5%	Confidential data supplied by major U.S. timber company
4. Cost of loading, ocean freight and insurance from U.S. to Sydney	\$US23.40/m^3	10%	Gollin Holdings Ltd. (1973) adjusted down by 10%
5. Cost of landing, wharfage, quarantine and importer's commission	\$A13.13/m^3	15%	Gollin Holdings Ltd. (1973)
6. Cost of transport and transfer from wharf to merchant's yard in Sydney	\$A2.48/m^3	10%	Current quotations

SOCIAL PRICE OF SAWLOGS IN MILLYARD

Import replacement cost was adopted as the basis for calculating the social price of sawlogs of radiata pine i.e. in terms of equation (6.1), it is equal to $(I + C_{ij} - H_j - M) R$. Complete details of the estimation of values for each of these parameters is provided in Appendix 6.1 (page A56) but some of the main issues involved are briefly reviewed here.

Import Replacement Price of Sawntimber at Key Market (I)

Values estimated for the cost and price components comprising the import replacement price of radiata pine sawntimber, their estimated coefficients of variation and the sources on which these estimates were based are summarized in Table 6.1.

The cost of importing Douglas fir framing into Sydney from North America was adopted as the starting point for calculating residual values for sawlogs. Sydney was assumed to be the key market for timber produced from the Region's plantations since most of the coniferous sawntimber imported into New South Wales enters this port and is sold in this market. Douglas fir framing from North America was the obvious choice for shadow-pricing because it represented about 23 percent of the volume of light framing timber used in New South Wales in 1968 (Working Party on Douglas Fir,

(1972) and it must have comprised well over 30 percent of the volume of light framing timber used in Sydney.

A single size and grade of Douglas fir framing imported in finished sizes was selected - kiln-dried, dimension (i.e. light framing), and construction grade timber, 102 mm by 51 mm nominal size, dressed on all four sides (S4S), in random length mixed dimension carloads (rail), f.o.b. at sawmill in the United States - hereafter referred to as Construction grade framing. The price series chosen for trend analysis was based on monthly quotations for this grade of timber published by the United States Department of Commerce in its Survey of Current Business.

Substantial shipping and other transfer costs must be incurred in order to deliver the timber to the merchant's yard in Sydney. These include the costs of packaging, freight from the sawmill to the wharf in the United States, wharfage and loading onto the ship in the United States, ocean freight and insurance from the United States to Sydney, landing, wharfage, quarantine and importer's commission in Sydney and transfer from the wharf to merchant's yard.

The final landed duty-free price at merchant's yard in Sydney was estimated to be $80.60/m^3 in 1972/73 Australian dollars. This figure was used as the base price for the average out-turn of framing timber anticipated from low-pruned trees over 35 cm d.b.h. or trees from fourth and later thinnings and from clear-fellings based on average sizes simulated for the strategies evaluated in this analysis. However, the base price was reduced subjectively by 10 percent for trees between 30 to 34.9 cm d.b.h. and 15 percent for trees less than 30 cm d.b.h. to take into account the greater proportion of low grade timber produced from these sizes because of their lower density. These adjusted values are shown in Table 6.2.

TABLE 6.2

Base prices for average tree sizes (d.b.h.) of radiata pine ($/m^3 sawn)

Average d.b.h. (cm)	$/m^3 sawn
Less than 30	74.1
30 to 34.9	76.3
35 and over	80.6

No adjustments were made for improvements in wood quality due to high pruning in alternative Forestry C particularly because of insufficient data but also because it seemed likely that part of the value added to the out-turn of framing grades by high pruning would be partly negated by larger branch-sizes in the unpruned sections of these trees.

Freight Cost from Mill to Key Market (H_j)

Two hypothetical sawmill sites were adopted one at Bega which would be central to the coastal plantations and the other at Bombala for Tableland plantations.

TABLE 6.3

Haulage distance and estimated freight cost for radiata pine sawntimber from Bega and Bombala to Sydney

Sawmill Location	Distance from Sydney (km)	Estimated Freight Cost ($/m^3)
Bega	420	7.20
Bombala	515	8.00

NOTE: Loading and unloading are incorporated in these costs.

The costs of hauling sawntimber from these two sawmills to the merchant's yard in Sydney is presented in Table 6.3 and were based on sawn haulage cost data reported in the E & M Bulletin[3] of the Forestry Commission of New South Wales. Their coefficient of variation was estimated to be 5 percent.

Cost of Sawmilling (M)

The cost of milling radiata pine sawlogs was based on a hypothetical sawmill of modern design specialising in the manufacture of kiln-dried, dressed framing timber.

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3. E & M Bulletin Economics and Marketing Bulletin which provided data on costs and prices as at 1 July 1973 on which the Forestry Commission of New South Wales bases its stumpage appraisal systems.

A mill capable of producing 220 m^3 of sawntimber per eight (8) hour shift per day was adopted, comparable to new mills constructed in Australia in recent years and in North America.

The average cost for the mill operating on one shift per day was estimated to be $34.21/$m^3$ and for two shifts per day, $29.24/$m^3$. The coefficient of variation was considered to be relatively large and was estimated to be 15 percent. This was because actual cost data were limited.

However, these costs seemed to be conservatively high when compared with cost of production estimates ranging from $19.47 to $28.29/$m^3$ reported for several United States sawmills.

Sawn Recovery (R_i)

A rough green sawn recovery of about 0.55 m^3 sawn/m^3 log volume was reported for the recently completed radiata pine sawmill in Victoria (Lembke, 1974). This is higher than the current average recovery for radiata pine of about 0.45 and it reflects both the modern design of the sawmill and the large size of the sawlogs compared with that being utilized by most Australian sawmills. Nevertheless a recovery of 0.55 is consistent with what could be expected of a sawmill of modern design (Koch, 1973, Presidents' Advisory Panel on Timber and the Environment, 1973) and is lower than that reported for a narrow-kerf, high-strain band mill in Canada which averaged 0.60 (Dobie, 1974).

A rough green sawn recovery of 0.55 was accepted for trees over 50 cm d.b.h. and, on the basis of studies by Humphreys (1970), Dobie (1967), Fahey and Hunt (1972), Mason, H.C. and Associates Inc. (1973) and the Presidents' Advisory Panel on Timber and the Environment (1973), the recoveries shown in Table 6.4 were estimated for other tree sizes.

The recoveries for the smaller tree sizes also seem conservative when compared with Dobie's (1974) results. They were based on a minimum tree size of 25 cm d.b.h., minimum small-end diameter (under bark) of 15 cm, and an average log length of 6 metres. The coefficient of variation of the sawn recovery values shown in Table 6.4 was estimated to be 10 percent.

TABLE 6.4

Sawn recoveries for different tree sizes

D.b.h. (cm)	Green-off-saw recovery (m^3 sawn/m^3 log volume)
Less than 30	0.40
30 to 34.9	0.45
35 to 39.9	0.50
40 to 49.9	0.53
50+	0.55

Value of Sawmill Chips

Green sawmill waste such as slabs, edgings, dockings and off-cuts was assumed to be converted into chips at the sawmill and then transported for sale to Edrom as chip exports.

Residual value pricing was again used to estimate the value of these chips because of the imperfect nature of the market for these chips. The following equation was adopted for determining the shadow prices of the chips:-

$$C_{ij} = (PB - X - H - G) \quad (0.90 - R_i) \qquad (6.2)$$

where C_{ij} and R_i are as previously defined in equation (6.1),

- P denotes the f.o.b. export price of the chips on the ship at Edrom in \$/BDMT,
- B denotes the average basic density of slabs, off-cuts and other green sawmill waste converted to woodchips in BDMT/m^3 solid chips,
- X denotes the cost of chip-piling and conveyorisation from the chipmill to the pile and from the pile to the ship at Edrom in \$/m^3 solid of chips,
- H denotes the cost of haulage, turn-around and unloading in \$/m^3 solid of chips,
- G denotes the cost of chipping at the sawmill in \$/m^3 solid of chips, and
- R_i is as previously defined for sawn recovery.

Because of the lack of suitable data, it was decided to adopt a conservative approach based on the export price of the woodchips rather than their import replacement cost which would have yielded much higher values.

The estimated values of these parameters, their estimated coefficients of variation and the sources on which the estimates were based are summarized in Table 6.5.

TABLE 6.5

Estimated values, accuracy and sources of data used to estimate the values of the components comprising the value of sawmill chips

Item	Symbol	Estimated Value	Coefficient of Variation	Source or Basis of Estimate
1. F.O.B. price of chips on ship at Edrom	P	\$27/BDMT		See Chapter 5
2. Basic density of the sawmill waste	B	.448 BDMT/m^3	10%	Shepherd (personal commun.)
3. Cost of chip-piling and conveyorisation	X	\$2.95/m^3	20%	See Chapter 5
4. Cost of chipping at mill	G			
5. Cost of haulage	H	\$0.03/m^3/km	10%	Ironside and Krilov (1973)
6. Cost of unloading and turn-around	H	\$0.20/m^3	5%	Own estimate
7. Sawn recovery R_i	R_i	See Table 6.4		
8. Value of sawmill chips by sawlog d.b.h.:				
(i) Less than 30 cm		\$3.00/m^3 log		
(ii) 30 to 34.9 cm		\$2.70/m^3 log		
(iii) 35 to 39.9 cm		\$2.40/m^3 log		
(iv) 40 to 49.9 cm		\$2.20/m^3 log		
(v) 50+ cm		\$2.10/m^3 log		

TABLE 6.6

Harvesting costs for various tree sizes and operations

D.b.h. (cm)	Harvesting cost ($/m^3)	
	Thinning	Clear-falling
Less than 30	2.8	2.7
30 to 34.9	2.3	2.2
over 34.9	2.0	1.9

Logging Costs

Harvesting costs, including felling, trimming, skidding and loading onto trucks using long-length operations, were estimated from data reported by Hall (1974). The resultant estimates are shown in Table 6.6.

As in the case of pulpwood logging the costs in Table 6.6 include a loading of 10 percent on Hall's data and an allowance of $0.25 per m^3 was also made for marketing and logging supervision. No reduction to these costs was made for clearfelling operations.

Haulage costs were estimated by firstly determining base rates for a short haul less than 20 km and for a long haul in excess of 20 km, and then adjusting the derived rates for differences between management areas with respect to topography and road standards.

Sawlog haulage costs were calculated on the same basis as those for pulpwood haulage except that total distances travelled per year adopted were considerably less - 36,000 km for the short hauls and 60,000 km for the long hauls. After adding the driver's wages, company overheads and the high risk profit allowance of 20 percent on average capital investment to the costs of owning and operating a $30,000 tandem-axle, diesel prime-mover and a trailer costing $4,000 (De Vries, 1973) average costs of 3.90 cents/m^3/km and 3.24 cents/m^3/km were derived for the short and long haul respectively.

TABLE 6.7

Haulage distance, average and total haulage costs for each Management Area

Management Area	Sawmill Location	Haulage Distance (km)	Haulage Cost	
			Average (c/m^3/km)	Total ($/m^3)
Bega	Bega	13	4.50	0.59
Bemboka	Bega	40	4.00	1.60
Burragate	Bega	65	4.50	2.93
Candelo	Bega	24	4.00	0.96
Cobargo	Bega	45	4.10	1.85
Lower Brogo	Bega	20	4.75	0.95
Pambula	Bega	50	4.10	2.05
Wyndham	Bega	50	4.10	2.05
Bondi	Bombala	28	4.00	1.12
Nungatta	Bombala	53	4.00	2.12

These were increased to 4.5 cents/m^3/km for the short haul and 4.0 cents/m^3/km for the longer haul to allow for the possibility of smaller, higher cost haulage units having to be used and to ensure against under-estimation because of unforeseen contingencies and estimation errors. Further adjustments were made to these base rates on the basis of the average road haulage conditions experienced between each Management Area and the two sawmills at Bombala and Bega. The haulage distance, average and total haulage costs adopted for each Management Area are shown in Table 6.7.

While little adjustment to the base rates was necessary in determining the average rates for most areas, the much higher rates adopted for Burragate and Lower Brogo Management Areas need further explanation. The long stretch of low standard unsealed road, something which is unlikely to alter in the future, was the main reason for adopting a rate of 4.5 cents/m^3/km for Burragate; for Lower Brogo the main contributing factor was the generally steeper topography of much of the area.

<u>Imputed Stumpage Prices</u>

The preceding estimates provide two different sets of stumpage prices - one based on the average cost of sawmilling on a one-shift per day operation and the other on two shifts per day operation. Although the two shift per day operation yields higher stumpage prices, it did not seem appropriate to apply these for some time to come. Very few mills in Australia, new or old, operate on two shifts per day, despite the savings which are possible in highly capitalized sawmills.

This is believed to reflect a general bias by labour, and especially by supervisory personnel and management, against two-shift operations in the industry. Nevertheless it is not the only reason since according to estimates by the Forestry Commission of New South Wales (FORWOOD, 1974a), there will not be a large enough volume of sawlogs available from the Region to support a sawmill operating on two-shifts per day until the year 2005. Therefore it was assumed that the prices for sawlogs processed from the Region for the next 30 years (up to the year 2004/5) will be based on a one-shift per day operation.

Beyond then, stumpage prices based on two-shift operations have been used in subsequent calculations not only because of the improved log supply situation but also because it is believed that changing technology and greater competition will require such a shift.

The resultant schedule of stumpage prices for the various tree size classes adopted and management areas is shown in Appendix 6.2 (page A78) and a comparison of existing

1972/73 Forestry Commission prices for Bondi Management Area with the imputed stumpage prices for the same area, both assessed on Bombala, is made in Table 6.8.

TABLE 6.8

Comparison of Forestry Commission stumpage prices as at 31st July, 1973 with imputed stumpage prices for Bondi Management Area ($/m^3)

D.b.h. Class	Forestry Commission of N.S.W. Stumpage Prices (I)			Imputed Stumpage Prices	
	Grade III	Grade II	Grade I	One-shift	Two-shift
Less than 30	4.12	4.12	4.12	11.59	13.57
30 to 34.9	4.35	4.35	4.35	14.37	16.61
35 to 39.9	4.55	4.55	4.55	18.23	20.71
40 to 49.9	4.85	6.51	9.51	19.18	21.81
50 plus	5.32	7.65	11.65	19.84	22.58

(I) Based on appraisal schedules operative from 1st July, 1973 for radiata pine included in the E & M Bulletin, Forestry Commission of New South Wales.

This comparison suggests that Forestry Commission prices are very conservative. However as pointed out earlier the determination of actual prices is carried out in an imperfectly competitive market and the differences shown in Table 6.8 may simply reflect lack of information. It could also reflect political influences or monopoly power in the bargaining process; or it may reflect some imperfections in the assumptions made in the residual value calculations in this study although an attempt was made to err on the conservative side in deriving the values for each parameter.

TABLE 6.9

Comparison of values of parameters used to estimate the stumpage prices for a sawlog of 35 to 39.9 cm d.b.h. at Bondi Management Area using the Forestry Commission appraisal system and the residual value method

Item	Forestry Commission System	Residual Value Method
Sawn price Sydney ($\$/m^3$)	57.62	80.60
Sawn haulage ($\$/m^3$)	8.00	8.00
Sawmilling cost ($\$/m^3$)	29.66	34.21 (one shift)
Value of chips ($\$/m^3$)	-	4.80
Sawn recovery ($\$/m^3$ sawn/m^3 log)	.4867	.50
Log haulage and logging costs ($\$/m^3$)	4.63	3.02

Finally the Commission's prices do not include any allowance for the value of chips recovered from mill waste; nor were they based on the levels of technology and markets assumed in this study.

Whatever the reason, the price of sawntimber assumed for the Sydney market seemed to represent a major contributing factor for the difference as can be seen in Table 6.9 where a comparison of values for the various parameters used to determine stumpage prices under each system is shown.

It is difficult to explain why the sawn price adopted by the Forestry Commission should be so much lower, particularly in view of the fact that the average landed cost of Douglas fir baulks imported into Australia from the United States in 1972/73 was approximately \$87.33m^3 based on an average f.o.b. value of \$55.98/m^3 reported by the Australian Bureau of Statistics (1974a) plus the costs of ocean freight, landing, wharfage, quarantine and commission. Furthermore the average realization value of sawntimber from one Australian radiata pine sawmill was reported to the writer to be \$95/m^3 in mid 1973/74, only one year after the base year adopted in this study.

LOWER AND UPPER BOUNDS

Because the imputed stumpage prices are themselves subject to uncertainty regarding various of the estimates and assumptions involved, it was decided to explore alternative approaches to price determination and to establish lower and upper bounds on these prices.

Lower Bounds

The preceding calculations assumed that all radiata pine sawlogs would be sold to local sawmills and the resulting timber sold in New South Wales, principally in Sydney. If these local markets do not eventuate, the logs could be sold to Japan, as is now the case with substantial volumes of radiata pine logs from New Zealand. The export trade in logs from New Zealand has grown steadily over the past decade, reaching 2 million m^3 in 1972. Most of these logs are shipped from the port of

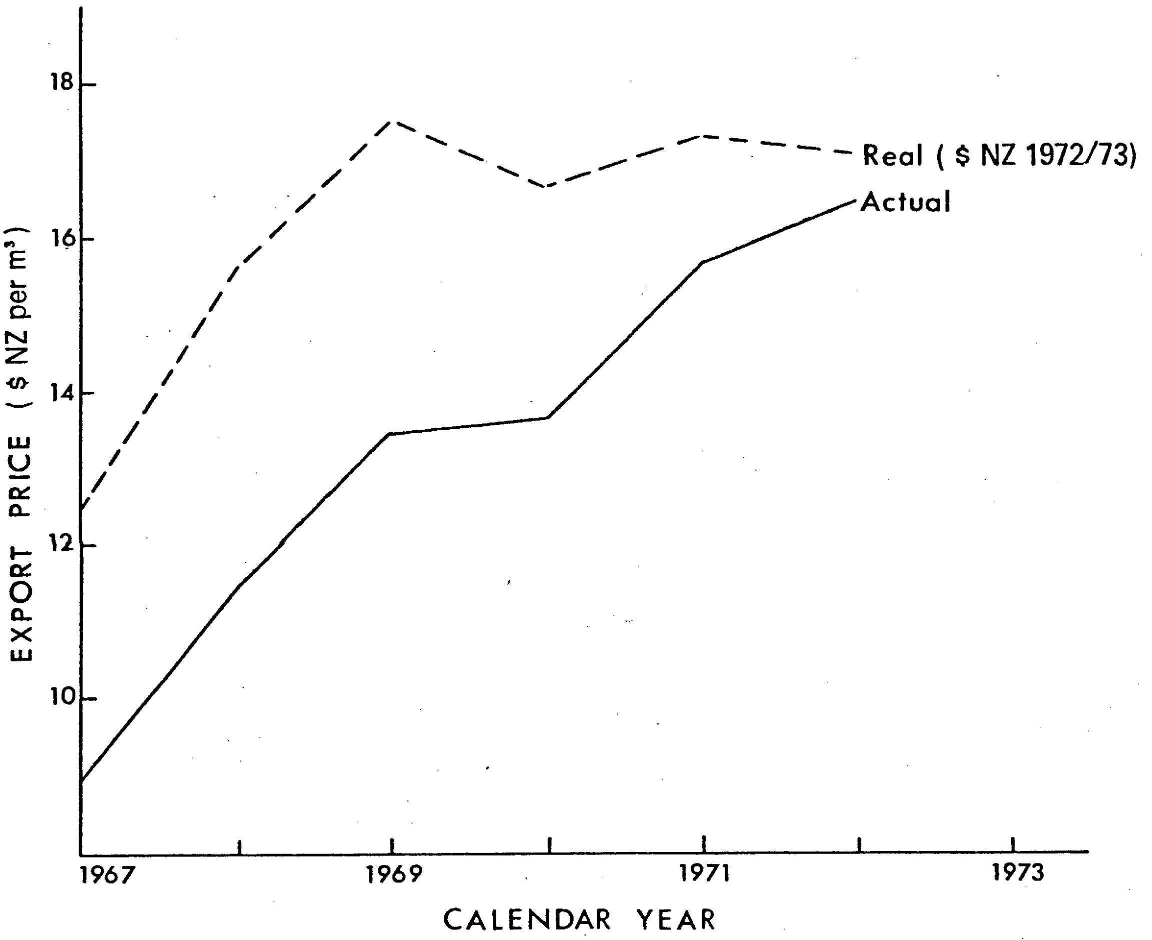


FIGURE 6.1 Trends in Actual and Real prices of sawlogs, consisting predominantly of Radiata Pine, exported from New Zealand.

Source: New Zealand Forest Service (1975)

Manganui which is located approximately the same distance from Japan as Edrom. Thus the prices received for these logs should be representative of potential export prices for radiata pine logs from the study area, assuming equivalent quality and size specifications can be met.

Japanese buyers stipulated a minimum small-end diameter of 15 cm diameter-over-bark (D.O.B.) for export logs and a reasonable degree of straightness. Sales were negotiated on a flat price per unit volume but the minimum proportions of logs within three length classes were stipulated (Fenton and Tustin, 1972). There seems to be little problem in meeting these specifications in sawlogs produced in the Lower South Coast Region.

The f.o.b. export prices received for New Zealand logs are shown in Figure 6.1 for the period 1967 to 1973. Real prices were derived by deflating to 1972/73 values using the Consumer Price Index for all commodities for New Zealand. Since 1969, real prices have been stable, averaging \$NZ17 per m^3, and this has been adopted as a basis for valuing logs from New South Wales.

This average price of \$NZ17 per m^3 corresponds to the Australian value in 1972/73 dollars since the exchange rate at that time was unity. The cost of wharfage and loading, estimated to be \$4.50/m^3 based on appropriately adjusted figures reported by Fenton and Tustin (1972) was deducted from this value giving an average price of \$12.50/m^3 for sawlogs delivered to port.

This figure was assumed to represent the price for an average tree size of 35 to 39.9 cm D.B.H. The prices for other sizes were calculated by adjusting this figure according to the ratios of the sawn recoveries for the size classes concerned, estimated earlier in this chapter (Table 6.4). Stumpage prices for sawlogs at the Management Area concerned were calculated by deducting the appropriate harvesting costs, using data developed earlier in the chapter and Edrom as the destination for all sawlog haulage. Details of the resultant prices are given in Appendix 6.3 (page A 79)

Upper Bounds

It is not so easy to establish definite upper bounds on prices. Perhaps the most important influence which has not been taken into account in the calculations so far is the possibility of a secular rise in the price of sawn timber and hence in the price of sawlogs. By the time any South Coast plantations on marginal farmland reach full production, this secular increase could have a marked impact on price and it has therefore been used as the basis for determining an upper bound.

A continued secular increase in the price of sawn timber has been forecast for the United States (Josephson and Hair, 1974), Canada (Manning and Grinnell, 1971) and Great Britain (Grayson, 1969), reflecting the ever-increasing pressures of population growth on a resource base (forest land) which is finite. However the expected rates of increase differ and specific examination of the issue seems desirable.

Wholesale prices for Construction grade framing of Douglas fir in the United States have shown an average rate of increase of 1.01% per annum in real terms since the early 1950's. Retail prices for Douglas fir and hardwood framing reported by the New South Wales Government Statistician in the annual Statistical Register of Social Conditions have increased by 1.05 and 1.16% per annum in real terms over the same period. On the other hand, wholesale prices for hardwood framing as recommended by the Associated Country Sawmillers of New South Wales have increased by only 0.11% per annum in real terms during the same period. The discrepancies between the rate of increases for hardwood and Douglas fir framing further serve to highlight the difficulties of using local prices as a basis for residual value calculations.

Ferguson (1974a) prepared forecasts of future average price and aggregate consumption for sawntimber in New South Wales. These forecasts were based on econometric analyses of New South Wales data, although there were acknowledged deficiencies in these, and on subjective adjustment later in this century to take the marked increase in plantation production into account. For the period to the year 2000, the average increase in real price implied by these forecasts was 0.25% per annum.

On the basis of these figures it was decided to increase the imputed prices calculated earlier at the rate of 0.50% per annum reaching an arbitrary upper limit 40 years hence. These upper limits at 40 years are shown in Appendix 6.4 (page A 80) for each Management Area and for the range of sizes adopted.

TABLE 6.10

Comparison of lower bound, most likely and upper bound stumpage prices for radiata pine sawlogs from Bondi Management Area ($/m³)

Price levels and Margins	Less than 30	30 to 34.9	35 to 39.9	40 to 49.9	50+
1. Lower bound	4.86	6.29	7.53	8.08	8.47
2. Most likely					
(a) One-shift per day	11.59	14.37	18.23	19.18	19.84
(b) Two-shifts per day	13.57	16.61	20.71	21.81	22.58
3. Upper bound					
(a) One-shift per day	14.15	17.54	22.26	23.41	24.22
(b) Two-shifts per day	16.59	20.28	25.28	26.63	27.56
4. Margins between lower bound and most likely:-					
1 and 2(a)	6.73	8.08	10.70	11.10	11.37
1 and 2(b)	8.71	10.32	13.18	13.73	14.11
5. Margins between most likely and upper bounds:-					
2(a) and 3(a)	2.56	3.17	4.03	4.23	4.38
2(b) and 3(b)	3.02	3.67	4.57	4.82	4.98

COMPARISON OF VARIOUS LEVELS OF STUMPAGE PRICES

The margins between the lower and most likely stumpage prices are much greater than those between the most likely and upper bound prices, which can be plainly observed in Table 6.10 where stumpage prices for each level and their differentials are shown for the complete range of sizes for Bondi Management Area.

The obvious inference is that the lower bound prices will make a greater impact on the economic worth of the plantations. Even so the probability of Australia becoming a net exporter of sawlogs as assumed in the lower bound prices is much more remote than the probability of sawlog prices rising in real terms. On the basis of present evidence, it is more likely that future prices will be somewhere in the range indicated by the most likely and upper bound values.

The margins between the lower bound and the most likely prices provide some indication of the high degree of protection resulting from freight costs on imported timber.

CONCLUSIONS

The independent appraisal of the sawlog prices resulted in values which were considerably higher than those based on the stumpage appraisal system of the

Forestry Commission of New South Wales inspite of attempts to be conservative. A comparison of the values of the parameters assumed under both appraisal systems indicated that the main difference lies in the prices adopted for radiata pine in the Sydney market. Such a discrepancy can only be explained either by differences in the bases for deriving the average value of the sawn out-turn from the plantations, or by the imperfectly competitive nature of the market for sawlogs. On the basis of price information available to the author, both factors seem to be relevant. The value of the key market price used in the residual stumpage appraisal system by the Commission need not bear any relation to the true market price for the commodities manufactured from the wood. In reality the method amounts to a cost plus approach, the normal procedure for pricing in a monopolistic market situation, rather than residual pricing. The prices imputed in this investigation therefore are probably more indicative of the true social value of sawlogs at the time large volumes become available on the New South Wales market in the future.

Because of the possibility of errors resulting from the assumptions made in the imputation procedure, lower and upper bounds were established. These will be used to test the sensitivity of the economic worth of the radiata pine plantations to price changes.

CHAPTER 7

PRICES FOR FARM PRODUCTS

Both dairying and beef-grazing are export-oriented industries, i.e. a major part of their output is sold on the world market - approximately one third in the case of dairying (Industries Assistance Commission, 1975) and 57 percent in the case of beef-grazing (Reeves and Hayman, 1975). Thus in a perfectly competitive market, price would be determined by the interaction of supply and demand in both the domestic and world markets. Since the quantity exported by any one country will be small relative to the total market, the influence of the exporting country on price will be negligible and the domestic price will approximate to the export price. Should the domestic price exceed the export price, producers will divert their production from the export market to the domestic market until prices in the two markets are equalized; and vice versa. This will occur irrespective of any restriction on imports.

On the other hand, where a single marketing organisation operates in place of the large number of independent producers as implied in the competitive market, the marketing body will be able to exercise its monopoly power by setting the domestic price for the exportable commodity at its import replacement price including any price effects from protection. Two prices will therefore exist - one for the domestic market which is at least equal to the import replacement price of the commodity; and a lower export price for the exportable surplus.

The method used to derive social prices for farm products will therefore be dependent on the nature of the existing markets. To simplify the estimation of these prices for dairy products and beef, three general assumptions were made.

Firstly, it was assumed that the domestic market is perfectly competitive. Therefore for those products which are exported such as beef and manufactured dairy products, the social value of the returns to the farmer will be based on their export price.

Secondly, it was assumed that the existing measures for protecting domestic markets for these commodities in other producing countries will remain unchanged even though in the absence of this protection, the resultant world price might be considerably higher than the existing price.

Thirdly, the small country assumption was adopted (Harris, 1964), i.e. Australia is assumed to be a relatively small exporter by world standards and therefore unable to influence world prices.

PRICES FOR DAIRY PRODUCTS

Three main markets for dairy products may be distinguished in Australia - the domestic market for fluid milk for human consumption (hereafter called fluid milk), and the domestic and export markets for manufactured products such as butter and cheese and skim-milk.

Just over 25 percent of the total milk production in Australia enters the domestic fluid milk market; for New South Wales, it is much higher at 56 percent (Industries Assistance Commission, 1975). The remainder is used for manufactured products, with the most important being butter and cheese which in 1974/75 utilized 50.9 and 13.9 percent of total Australian milk output respectively.

The supply of fluid milk in the domestic market is controlled by means of quotas (or contracts) in nearly all States (Industries Assistance Commission, 1975).

It is rationed according to the demand for fluid milk at a price fixed by individual milk authorities in each State. The prices paid for fluid milk are generally much higher than the prices of milk sold for manufacture. Milk in excess of quota is used for manufacturing purposes and therefore paid at manufacturing milk prices.

Bulk wholesale ex-factory prices for butter and cheese are determined by the Australian Dairy Industry Council, subject to approval by the Prices Justification Tribunal, while prices for skim-milk powder and casein in the domestic market are fixed by the Skim Milk Powder Equalisation Advisory Committee and the Casein Equalisation Advisory Committee. The marketing of manufactured dairy products for export is controlled by the Australian Dairy Corporation which, subject to agreement by the industry, may be given monopoly trading powers in specific markets.

Because of the two-price market system which exists for manufactured dairy products, separate price equalisation schemes have been developed for each of butter, cheese, skim-milk powder and casein. Returns from the sale of these products to the domestic and export markets are pooled and a weighted average or equalized price for each product is paid to the manufacturer. The schemes are strictly voluntary and at least until the recent discontinuation of the butter and cheese bounties, have included most manufacturers.

While equalisation has enabled returns to the producer to be stabilized, some misallocation of resources is inevitable since the marginal returns to farmers will be higher than the marginal returns they would have received in a competitive market (Bureau of Agricultural Economics, 1975a).

It is therefore apparent that because of the highly organised and institutionalised marketing arrangements for dairy products, considerable monopoly power is vested in the organisations controlling the supply and pricing of fluid milk and manufactured milk products. The home consumption price-fixing arrangements have resulted in large differentials between domestic and export prices for the same product. Restrictions on the supply of fluid milk have led to higher prices than otherwise would have obtained.

These pricing arrangements represent the main form of protection to the dairy industry in Australia. The Industries Assistance Commission (1975) has estimated that the maximum level of transfers from consumers to producers of butter and cheese in 1974/75 as a result of the domestic price arrangements were 35 and 23 percent respectively of the total realisations received.

Other forms of protection are provided through (a) the various tariff and non-tariff barriers to imports of dairy products and margarine, (b) the tacit agreement between the New Zealand and Australian dairy industries with respect to trade in manufactured dairy products, (c) quarantine restrictions, (d) financial assistance under the Dairy Industry Adjustment and Rural Reconstruction Schemes and (e) other forms of State assistance through research, agricultural extension and so on. Collectively however, they represent only limited assistance.

Because of the domestic price arrangements and various government interventions, both in relation to marketing and production, the markets for dairy production do not conform to the perfectly competitive model implied in the economic efficiency goal adopted in this study. Thus the residual value approach to pricing of these commodities was adopted using their export prices as the starting point for imputation purposes. The only exception is fluid milk which can only be produced locally because of its perishable nature. Some adjustment to its price is therefore needed in determining its social value.

Prices for Fluid Milk

In Chapter 1, it was pointed out that approximately 29 percent of the Region's production was utilised for fluid milk. This is much lower than the proportion of

56 percent supplied by the whole New South Wales dairy industry, but because of its inclusion in the fluid milk quota system administered by the Dairy Industry Authority of New South Wales, potential for expansion seems likely. Nevertheless the bulk of the fluid milk produced from the Region is supplied to the Australian Capital Territory where the Milk Authority there regulates its supply, pricing and distribution. The Bega Cooperative Society Ltd. which supplies most of this milk operates its own quota system among its members for the supply of milk to the Australian Capital Territory. The quotas regulated by the Dairy Industry Authority are treated separately from those administered by the Bega Cooperative.

Fluid milk for human consumption is differentiated from the rest of the industry because of its perishability and different market characteristics. Its perishable nature largely eliminates any threat of competition from imports. Furthermore, a recent study of the Sydney fluid milk market showed only the fluid milk price and the age structure of the population as statistically significant determinants of the demand for fluid milk whereas income did not appear to be an influencing factor (Street, 1974). However the study also suggests that, in the long run, the demand for fluid milk is relatively unresponsive to small changes in fluid milk prices (in real terms). Prices and margins can therefore be maintained in real terms free of any serious long term demand repercussions simply by adjusting for movements in costs.

Nevertheless raw milk is a relatively uniform commodity irrespective of its source and the form of its utilisation. Therefore it is apparent that the producers of fluid milk will not only benefit from the artificially set price differential relative to milk for manufacture but also from the protection provided to manufactured milk products. The removal of protection to manufactured milk products would induce farmers supplying milk to these outlets to turn to the more profitable, more highly priced milk market which would induce an overall fall in the price for fluid milk (Gruen, 1972).

Gruen estimated the cost of this protection to be equal approximately to the difference between the overseas price for cheese and the overall return to cheese from the equalisation scheme. In 1972/73 this was estimated to be 20.9 cents/kg or 2.3 cents/litre of milk equivalent based on data reported by the Commonwealth Dairy Produce Equalisation Committee Ltd. (1973) and assuming a conversion factor of 0.11 kg of cheese/litre of milk. Thus the financial return to the dairy farmer for fluid milk would be adjusted down by this amount.

An alternative, more complex approach has been described by the Bureau of Agricultural Economics (1975a). An upper limit to the level of protection given the fluid milk sector through price-fixing may be equal to the rate applicable in the manufacturing sector for bounty and manufacturing milk sector's price-fixing arrangements plus the differential in milk payments between fluid milk and manufacturing milk. However it does not represent the true level of protection from the pricing arrangements in the fluid milk sector alone since there are additional input costs in the form of ensuring continuity of supply and penalties for inferior quality and quota shortfalls. Thus the true level of protection probably lies somewhere between the level of protection for manufactured milk and the maximum level referred to previously. Since it was difficult to estimate the cost of protection included in the price of fluid milk by this method, it was decided to opt for the simpler rule of thumb suggested by Gruen (1972). It is interesting to note, however, that the effective rate of protection to the fluid milk sector of the New

South Wales dairy industry ranged from 28 percent to 364 percent using the approach adopted by the Bureau of Agricultural Economics (1975a) above or about 15 percent of gross farm returns in the case of the minimum level.

For simplicity all fluid milk was assumed to be sold to the Australian Capital Territory. The delivered price of 11.7 cents/litre in 1972/73 was adopted (Milk Authority of the Australian Capital Territory, 1974). After adjusting for cartage of 1.1 cent/litre from Bega to Canberra, a distance of 304 km at a rate of 0.00362 cent/litre/km (Bendall, personal communication) and for the distortion due to indirect protection of 2.3 cents/litre, the return to the factory at Bega was estimated to be 8.3 cents/litre. In view of the wide range of values estimated for the effective rate of protection by the Bureau of Agricultural Economics (1975a), this value of 8.3 cents/litre must be regarded as rather high and must therefore be representative of an upper limit to the social value of the returns to the dairy farmers for fluid milk.

<u>Prices for Milk for Manufacture</u>

In Chapter 1, dairy production from the Region was shown to be utilized principally in one or more of three ways, including in addition to fluid milk for human consumption, milk for cheese manufacture and cream for butter manufacture. Thus it was assumed that milk for manufacture will be used in the production of either cheese or butter. Since each of these commodities is heavily dependent on exports, then in a perfect market situation the return to the producer at the farm gate will be determined by their respective export prices using the residual value approach.

Return to Farmer at Factory Door for Butter

The social value of the return to the farmer at the factory door (P_b) was determined from the following equation:-

$$P_b = (X_b - M_b - C_b)\ L_b \qquad (7.1)$$

where X_b denotes the export price for butter on agent's floor in Sydney in cents/kg,

M_b denotes the manufacturing margin for butter in cents/kg,

C_b denotes the cost of cartage from factory to agent's floor in cents/kg, and

L_b denotes the ratio for converting a kilogram of butter to a litre of milk.

Again because of the fluctuation in world prices for butter, a trend value was estimated for X_b by fitting the following linear regression to the average annual value for sales of butter overseas which have been taken into account for equalisation purposes during the period 1953-54 to 1972-73 (Commonwealth Dairy Produce Equalisation Committee Ltd., 1974), expressed in 1972/73 money values using the Consumer Price Index All Groups Australia:-

$$\ln X_b = 4.8416 - 0.0395t \qquad (7.2)$$

where $\ln X_b$ denotes the logarithm of the average annual price on overseas sales of butter in 1972/73 cents/kg, and

t denotes the number of years since 1952/53.

The equation had a correlation coefficient of 0.88 and the slope was significantly different from zero at the 0.99 probability level. A trend value of 57.4 cents/kg was estimated for butter in 1972/73 and is higher than the actual price of 54.2 cents/kg in that year.

The manufacturing margin, M_b, was based on the assessed manufacturing cost of 11.8 cents/kg which was reported by the Commonwealth Dairy Produce Equalisation Committee Ltd. (1974) for 1972/73.

A cartage cost of 1 cent/kg was subjectively estimated based on the rate of 2.6 cents/tonne/km from the butter factory at Cobargo to Sydney, a distance of 390 km.

Using a conversion factor (L_b) of 0.05 kg butterfat/ litre of milk, the return to the farmer at the factory was estimated to be 2.23 cents/litre.

Return to the Farmer at Factory Door for Cheese

This was determined in much the same way as the return for butter:-

$$P_c = (X_c - M_c - C_c)\ L_c \qquad (7.3)$$

where P_c, X_c , M_c, C_c and L_c are identical to P_b, X_b, M_b, C_b and L_b but substituting cheese for butter.

A trend value was again derived for X_c by fitting the following linear regression to the average annual value of overseas of cheese taken into account for equalisation purposes for each year in the period 1953/54 to 1972/73 (Commonwealth Dairy Produce Equalisation Committee Limited, 1974), expressed in 1972/73 values in the usual way:-

$$\ln X_c = 4.2755 - 0.0242t \qquad (7.4)$$

where $\ln X_c$ denotes the logarithm of the average annual prices for cheese sold overseas in 1972/73 cents/kg, and

t is as previously defined.

The correlation coefficient for this equation was 0.68 and the slope value was significantly different from zero at the 0.99 probability level. The trend value estimated for cheese in 1972/73 by means of equation (7.4) was 44.3 cents/kg which is less than the average price of 46.3 cents actually received in that year. A manufacturing margin, M_c, of 17.2 cents/kg was adopted. Because no assessed manufacturing cost was reported for 1972/73, it was necessary to estimate this cost by adjusting the cost of 19.2 cents/kg reported for 1973/74 (Commonwealth Dairy Produce Equalisation Committee Ltd., 1974) downwards by the same percentage decrease of 10.45 percent as that estimated for butter manufacturing costs (Commonwealth Dairy Produce Equalisation Committee Ltd., 1973 and 1974). Cartage was again based on 2.6 cents/tonne/km thus yielding a cost of 1.09 cents/kg based on haulage from Bega to Sydney, a distance of approximately 420 kms. Using a conversion factor (L_c) of .11 kg of cheese/litre of milk, the return to the farmer at the factory (P_c) was estimated to be 2.86 cents/litre.

Prices at Farm-gate

"At farm-gate" returns were calculated by deducting the cost of cartage for milk (or its equivalent in the case of butter) from farm to factory from the returns to the farmer at the factory. Suitable data were not available however, and it was necessary to estimate the freight cost by other means. Since most of the fluid milk for human consumption or for cheese manufacture is transported in tankers rather than in cans, farm to factory cartage was estimated to be 0.00434 cents/litre/km based on Bendall's (personal communication) estimate of 0.00362 cents/litre/km plus 20 percent to cover the additional costs associated with lower standard roads, time lost at pick-up at each farm and the shorter hauls involved. For cream it was assumed that only cream is sent to the factory with the residual skim milk fed to either pigs, replacement calves and for the rearing of calves for vealers, even though this is considered to be a less efficient method of utilisation than transportation of chilled milk for separation into cream and skim milk powder (Standen, 1970). It has been adopted because it is currently the main method of supply to the Bemboka and Cobargo factories. Assuming one litre of cream weighs one kilogram, the cost per litre of milk equivalent using the farm-to-factory cartage rates of 0.00434 cents/litre/km for fluid milk would be 0.00022 cents/litre/km. This was increased to 0.0003 cents/litre/km to include the extra cost of cans and the smaller size of the haulage unit.

Most Likely Prices for Dairy Production

Because of the price differentials which exist between the three commodities, returns to the individual dairy farmer in the Region will depend very heavily on the pattern in which his milk is utilised. The most likely price for milk production was therefore based on the forecast pattern of utilisation in the Region. This was predicted to be 45 percent cheese, 35 percent fluid milk and 20 percent butter which is much the same as the existing pattern with the exception that the production of butter was expected to decline relative to the other two commodities largely as a result of the anticipated closure of the Bemboka factory. It was considered that the relative proportion of production used for fluid milk would be maintained at least at the present level and would increase slightly owing to the inclusion of the Region in the Sydney wholemilk supply zone. Furthermore, the strong demand for cheese from the Region should ensure that an increasing share of total output is diverted to this commodity. Most likely prices for each Management Area are presented in Table 7.1.

TABLE 7.1

Estimated prices for dairy production (cents/litre)

Management Area	Distance (km) from		Estimated prices (costs/litre)		
	Bega	Cobargo	Most likely	Lower	Upper
Bega	13	55	4.59	2.80	8.24
Bemboka	40	82	4.50	2.69	8.13
Bondi	110	152	4.24	2.38	7.82
Burragate	65	107	4.41	2.58	8.02
Candelo	24	66	4.55	2.76	8.20
Cobargo	45	12	4.48	2.66	8.10
Lower Brogo	20	22	4.56	2.77	8.21
Nungatta	102	144	4.28	2.42	7.86
Pambula	50	92	4.46	2.64	8.08
Wyndham	50	92	4.46	2.64	8.08

Lower and Upper Bounds

Because the expected pattern of utilisation was based on subjective estimates of future trends that may be subject to error, a sensitivity test to determine the effects of extreme price changes was carried out. For the upper bound case, it was assumed that all milk would be eventually utilised as fluid milk for human consumption. The lower bounds were based on the assumption that all milk would be used for cheese manufacture. Lower and upper bound prices for each Management Area are also shown in Table 7.1.

PRICES FOR BEEF CATTLE

The beef cattle industry is probably the least protected of Australia's rural industries. The Bureau of Agricultural Economics (1975b) estimated that the effective rate of protection for the beef industry in Australia was 3.9 percent and only 1.2 percent in New South Wales. The markets for beef cattle very nearly fit the perfectly competitive model with little or no attempt being made to adjust supply and demand or to prevent the entry of imports. As would be expected in such a market, price is the main equilibrating mechanism.

Producers have therefore generally adopted a selling policy of meeting the market i.e. endeavouring to turn off cattle as they reach the desired slaughter condition, consistent with the farmer's aims for herd management (ibid.). The general acceptance of such a policy arose because of the sense of security engendered in the industry by expanding beef markets throughout the 1960's and into the early 1970's in conjunction with rising real prices. The stability in these prices, however, has disappeared in the last three years primarily because of the increasing dependence of the industry on world markets which are extremely sensitive to a variety of factors affecting world supply and demand (Reeves and Hayman, 1975). Prices are now at an all-time low and they are not anticipated to recover for some time (Bureau of Agricultural Economics, 1975c).

The Australian domestic market still rates as the industry's largest single market. Demand from domestic consumers is relatively price elastic but exhibits only a small positive response to income movements (Bureau of Agricultural Economics, 1975c). Demand in other countries is also relatively price elastic but in contrast to the Australian situation is also responsive to income changes. Therefore assuming real incomes in the importing countries begin to increase again as they had been before the recent market slump, a resurgence in demand can be anticipated and prices for beef should recover to at least pre-1973 levels.

It is essential for the future profitability of the beef industry that a recovery in the world's markets does take place because saleyard prices for beef cattle in Australia are strongly influenced by export prices particularly for exports to the United States of America (Papadopolous, 1973). Because of this influence and the competitive nature of the domestic beef market, at least at the producers' level, the saleyard price for beef cattle will reflect the price situation in the world market. It can therefore serve as a useful approximation of the social price for cattle.

However because of the fluctuations in beef cattle prices in recent years, the estimation of a trend value was considered necessary. It was based on annual average price data for first and second export quality ox at Homebush for the period 1953/54 to 1972/73 (Bureau of Agricultural Economics, 1973). They were firstly converted to real 1972/73 prices using the Consumer Price Index All Groups Australia and then the following linear relationship was fitted:-

$$\ln P_t = 3.9601 + 0.0168t \qquad (7.5)$$

where $\ln P_t$ denotes the logarithm of the average price of first and second class ox at Homebush expressed in 1972/73 dollars per kg, and

t denotes the number of years since 1952/53.

The correlation coefficient for the equation was 0.62 and the slope was significantly different from zero at the 0.99 probability level. The trend value for 1972/73 was estimated to be 73.4 cents/kg dressed weight which at a dressing rate of 53 percent is equivalent to approximately 39 cents/kg live weight. This value was adopted as the price paid for steers at Homebush since a close relationship was found to exist between steer prices and those for first and second export quality ox based on data reported in The Land newspaper. The prices paid for other classes of cattle were calculated by firstly estimating the margins between these and steers at Homebush in the period of the boom years of 1973 and 1974 and then adjusting the trend value of 39 cents/kg according to these margins. The prices determined for vealers, heifers and cows on this basis were 42, 37 and 35 cents/kg respectively and were applied to all Management Areas. A deduction of 1 cent/kg was made from the Homebush prices to cover cartage and handling.

Lower and Upper Bound Prices for Beef Cattle

As indicated in the estimation of the trend value, beef prices at Homebush have risen over the past 20 years at an estimated rate of 1.7 percent per annum in real terms. In spite of the current depressed market for beef, most market experts expect prices to recover in the long term although it is unlikely that they will maintain the rate of increase observed in the 1960's. This is particularly apparent in the trend in prices over the period from 1965/66 to 1972/73 when prices tended to stabilize in real terms and even to decline. It is important to test the sensitivity to possible price changes particularly in view of the findings by McCarthy et al. (1970) that the price of beef has a significant impact on the economic return to the farmer.

Therefore the lower bound prices were based on a one percent per annum decrease over the next 20 years and then remaining stationary. This approximates to the downward trend in real prices over the period 1965/66 to 1972/73.

The upper bound prices were based on resumption of 1.7 percent increase in real prices during the period of the data used to determine the trend value. Again as for the lower bounds, it was assumed that this would terminate after 20 years thereafter remaining stationary.

CHAPTER 8

RESULTS OF THE COMPARATIVE ANALYSIS

INTRODUCTION

In this chapter, the present values of the net social benefits per hectare for the three land uses are compared. The main discussion is centred on the results based on the most likely estimates of costs, prices, yields as well as the discount rate. The sensitivity of the net social benefit criterion to changes in two key parameters, the discount rate and product prices, is also examined, and reference is made to the impact of possible changes in costs and yields. In all, results are reported for ten Management Areas - Bega, Bemboka, Bondi, Burragate, Candelo, Cobargo, Lower Brogo, Nungatta, Pambula and Wyndham. The analysis is therefore not restricted to just a comparison of three land uses but may assist the identification of the Management Areas which appear to be best-suited for any one particular use. Furthermore the strategy with most potential for production under each land use is considered.

MOST LIKELY OUTCOMES

Present values per hectare for the three land uses are presented in Table 8.1 for operations commencing in the periods 1975/76 to 1979/80 and subsequent to and including 2005/6 and represent social benefits minus social costs discounted to each of these periods. These two periods were considered separately in order to evaluate the impact of the structural changes assumed for the sawmilling and pulp industries in the Region on the shadow prices for wood products.

TABLE 8.1

Present values per hectare of net social benefits from dairying, beef grazing and radiata pine plantations based on MOST LIKELY estimates of costs and prices and a discount rate of 5 percent

Management Area		FORESTRY A		FORESTRY B			FORESTRY C			Dairying		Beef Grazing	
		Rotation 15 years	Rotation 20 years	Rotation 30 years	Rotation 35 years	Rotation 40 years	Rotation 30 years	Rotation 35 years	Rotation 40 years	A	B	A	B
Bega	(1)	n.c.	18	1148	1459	1382	1961	1872	1746	150	-486	392	93
	(2)	-117	18	1355	1666	1590	2089	2000	1874	150	-486	"	"
Bemboka	(1)	n.c.	-133	998	1315	1249	1785	1704	1589	113	-506	"	"
	(2)	-255	-133	1177	1494	1428	1914	1833	1717	113	-506	"	"
Bondi	(1)	-174	471	1517	1865	1793	2537	2474	2342	6	-565	"	"
	(2)	298	471	1748	2096	2026	2707	2644	2512	6	-565	"	"
Burragate	(1)	-234	320	989	1296	1232	1587	1513	1410	76	-527	"	"
	(2)	160	320	1197	1505	1441	1716	1641	1538	76	-527	"	"
Candelo	(1)	-476	55	1118	1429	1354	1901	1815	1692	134	-495	"	"
	(2)	-83	55	1326	1637	1562	2029	1943	1820	134	-495	"	"
Cobargo	(1)	n.c.	-181	1273	1644	1590	2445	2385	2260	105	-511	"	"
	(2)	-299	-181	1445	1816	1762	2615	2555	2430	105	-511	"	"
Lower Brogo	(1)	n.c.	-171	1067	1384	1314	1891	1806	1684	138	-492	"	"
	(2)	-291	-171	1238	1555	1485	2019	1934	1812	138	-492	"	"
Nungatta	(1)	-108	544	1404	1752	1688	2337	2280	2159	22	-556	"	"
	(2)	364	544	1636	1984	1921	2507	2450	2329	22	-556	"	"
Pambula	(1)	-206	350	1105	1410	1338	1735	1654	1542	97	-515	"	"
	(2)	188	350	1313	1618	1546	1863	1782	1670	97	-515	"	"
Wyndham	(1)	-372	169	1034	1344	1275	1726	1646	1535	97	-515	"	"
	(2)	22	169	1242	1552	1484	1854	1774	1663	97	-515	"	"

n.c. not calculated. (1) denotes Planning Period 1975/76 to 1979/80. (2) denotes Planning Period subsequent to and including 2005/6.

The results in Table 8.1 clearly show that the most economic alternatives are Forestry B and C; i.e., the radiata pine strategies which are directed at the production of sawlogs rather than pulpwood. For example, in Bega Management Area which was considered to be a farming area of average site quality for radiata pine plantations (site index 24), the present values per hectare for Forestry B and C planted in the period 1975/76 to 1979/80 were $1,459 and $1,961 respectively for the most profitable rotation compared with $150 and $-486 for Dairying A and B and $392 and $93 for Beef Grazing A and B. In the higher site quality country of Bondi Management Area, present values of $1,865 and $2,537 per hectare were calculated for Forestry B and C respectively, $6 and $-565 for Dairying A and B and again $392 and $93 for Beef Grazing A and B.

Forestry A yielded much lower present values than the other two radiata pine plantation strategies, but even this alternative proved more economic than either the dairying or beef grazing strategies in some Management Areas. For the most economic of the two rotation lengths evaluated, 20 years, this strategy yielded higher present values than Dairying A and B in Bondi, Burragate, Nungatta, Pambula, and Wyndham Management Areas and than Beef Grazing A and B in Bondi and Nungatta Management Areas.

The least economic of the three land-use alternatives was dairying, but some potential for this land use still exists in areas close to the Bega factory such as in Bega, Bemboka, Candelo, Cobargo and Lower Brogo Management Areas provided farmers are given the incentives to adopt more efficient farming methods and are permitted access to the fluid milk markets. If, for equity reasons, radiata pine plantations were to be excluded from these Management Areas in favour of dairying, it is unlikely that the net social benefit derived from plantations in other Management Areas would be significantly less. However, much would depend on the scale of any plantation project needed to satisfy the demand for wood products from the Region.

Beef grazing seems to represent a better farming alternative in the long term in spite of the serious plight of this industry at the present time. However, this will be very much influenced by market prospects, particularly with respect to prices. The integration of beef grazing and forestry is one possibility that must be considered (see Borough and Reilly, 1976; and Ferguson and Reilly, 1977) but again it must be treated with some caution until many of the technical problems associated with it have been resolved.

The optimum rotation lengths for Forestry A, B and C appear to be in the vicinity of 20, 35 and 30 years respectively but because of the limited range of options evaluated they should be regarded as indicators only. A more interesting feature was the relatively small gain in present value due to the impact of structural change on shadow prices. For Forestry B and C where the impact can be seen clearly, the difference between the values estimated for operations commencing in 1975/76 to 1979/80 were between $100 and $250 per hectare lower than in the period subsequent to 2005/6 when sawmills will be operating on a two shift per day basis. For Forestry A the present values per hectare were increased substantially by about $400 for the only rotation, 15 years, which could be examined satisfactorily.

RESULTS BASED ON LOWER BOUND SHADOW PRICES

The scenario of results alters quite dramatically when the lower bound prices for the various products are considered (see Table 8.2). In none of the Management Areas was there an economic surplus (i.e., a positive present value per hectare) registered for Forestry A, Dairying A and B and Beef Grazing B. In only Bondi and Nungatta Management Areas (the high site quality farming areas) and Pambula was a positive present value recorded for Forestry B although an additional area, Burragate

TABLE 8.2

Present values per hectare of net social benefits from dairying, beef grazing and radiata pine plantations based on LOWER BOUND shadow prices for products MOST LIKELY costs and yields and 5 percent discount rate

Management Area	FORESTRY A Rotation 15 years	FORESTRY A Rotation 20 years	FORESTRY B Rotation 30 years	FORESTRY B Rotation 35 years	FORESTRY B Rotation 40 years	FORESTRY C Rotation 30 years	FORESTRY C Rotation 35 years	FORESTRY C Rotation 40 years	Dairying A	Dairying B	Beef Grazing A	Beef Grazing B
Bega	n.c.	n.c.	-386	-268	-256	-234	-235	-244	-589	-891	93	-10
Bemboka	n.c.	n.c.	-480	-361	-347	-371	-367	-363	-635	-916	"	"
Bondi	-618	-515	10	118	119	261	258	232	-763	-986	"	"
Burragate	-599	-508	-81	25	18	47	33	7	-680	-941	"	"
Candelo	-840	-771	-350	-233	-224	-199	-202	-213	-606	-900	"	"
Cobargo	n.c.	n.c.	-516	-379	-349	-331	-317	-309	-647	-923	"	"
Lower Brogo	n.c.	n.c.	-504	-384	-364	-399	-395	-393	-602	-898	"	"
Nungatta	-545	-449	68	189	186	328	323	294	-747	-977	"	"
Pambula	-571	-478	-50	55	46	75	60	32	-656	-927	"	"
Wyndham	-737	-659	-235	-123	-120	-94	-101	-119	-656	-927	"	"

Management Area , produced a similar result under Forestry C. Beef Grazing A, however, provided the best overall result but because the same prices were adopted for all Management Areas, this could be misleading.

Where positive present values arose, they were consistently low. However, the probability of these lower bound prices ever prevailing for any length of time is relatively small, particularly in the case of the plantation alternatives. Even so, the results again reinforce the concept of integrating beef with plantation forestry for long-term land use in the Region's farming areas.

RESULTS BASED ON UPPER BOUND SHADOW PRICES

Dairying proved to be an extremely economic form of land-use for the first time but it must be stressed that the upper bound prices were based on the assumption that all milk would be sold as fluid milk (or whole milk) for human consumption. Although such a price situation may be a possibility in the long term, it must be regarded as an unlikely development in the forseeable future.

Forestry B and C strategies again generated the largest present values overall and beef grazing, particularly the more intensive alternative, Beef Grazing A, again compared more than favourably. Dairying A, however, resulted in higher present values than Beef Grazing A.

The main conclusion is that dairying under intensive management is only likely to be a desirable form of land-use in the long term if most of the production can be sold as whole-milk for human consumption, the high-priced segment of the market.

TABLE 8.3

Present values per hectare of net social benefits from dairying, beef grazing and radiata pine plantations based on UPPER BOUND shadow prices for products, MOST LIKELY costs and yields and 5 percent discount rate

Management Area	FORESTRY A		FORESTRY B			FORESTRY C			Dairying		Beef Grazing	
	Rotation 15 years	Rotation 20 years	Rotation 30 years	Rotation 35 years	Rotation 40 years	Rotation 30 years	Rotation 35 years	Rotation 40 years	A	B	A	B
Bega	-54	86	1815	2193	2098	2796	2683	2524	1659	339	1058	320
Bemboka	-204	-77	1605	1990	1908	2583	2478	2333	1614	315	"	"
Bondi	395	577	2274	2698	2612	3553	3470	3303	1486	244	"	"
Burragate	245	412	1606	1980	1902	2339	2242	2112	1568	290	"	"
Candelo	-18	126	1777	2155	2062	2723	2612	2459	1643	330	"	"
Cobargo	-252	-129	1937	2387	2319	3442	3363	3205	1601	308	"	"
Lower Brogo	-243	-120	1681	2065	1980	2713	2603	2450	1647	333	"	"
Nungatta	466	655	2132	2556	2477	3307	3230	3078	1502	251	"	"
Pambula	277	447	1746	2118	2029	2518	2414	2274	1593	303	"	"
Wyndham	97	251	1669	2046	1962	2508	2405	2265	1593	303	"	"

TABLE 8.4

Present values per hectare of net social benefits from dairying, beef grazing and radiata pine plantations based on MOST LIKELY estimates of costs and prices and a discount rate of 6 percent

Management Area		FORESTRY A		FORESTRY B			FORESTRY C			Dairying		Beef Grazing	
		Rotation 15 years	Rotation 20 years	Rotation 30 years	Rotation 35 years	Rotation 40 years	Rotation 30 years	Rotation 35 years	Rotation 40 years	A	B	A	B
Bega	(1)	n.c.	-46	718	895	803	1316	1213	1087	125	-405	327	77
	(2)	-134	-46	894	1071	979	1420	1317	1192	125	-405	327	77
Bemboka	(1)	n.c.	-159	610	794	711	1188	1093	976	94	-422	"	"
	(2)	-241	-159	762	946	863	1292	1197	1080	94	-422	"	"
Bondi	(1)	-233	294	993	1194	1101	1735	1646	1510	5	-471	"	"
	(2)	187	294	1190	1391	1298	1873	1784	1648	5	-471	"	"
Burragate	(1)	-262	180	613	793	713	1044	956	849	63	-439	"	"
	(2)	80	180	790	970	890	1149	1060	954	63	-439	"	"
Candelo	(1)	-449	-19	697	875	785	1272	1172	1049	112	-413	"	"
	(2)	-108	-19	874	1052	962	1376	1276	1154	112	-413	"	"
Cobargo	(1)	n.c.	-193	811	1028	947	1953	1855	1708	87	-426	"	"
	(2)	-272	-193	955	1172	1091	2107	2009	1862	87	-426	"	"
Lower Brogo	(1)	n.c.	-188	659	842	755	1265	1166	1043	115	-410	"	"
	(2)	-268	-188	805	987	900	1369	1270	1147	115	-410	"	"
Nungatta	(1)	-172	348	915	1118	1032	1867	1773	1631	19	-463	"	"
	(2)	238	348	1112	1314	1229	2021	1926	1785	19	-463	"	"
Pambula	(1)	-240	203	697	873	787	1152	1058	944	81	-430	"	"
	(2)	102	203	874	1050	963	1256	1162	1048	81	-430	"	"
Wyndham	(1)	-368	67	641	820	736	1145	1051	938	81	-430	"	"
	(2)	-27	67	817	997	913	1249	1156	1042	81	-430	"	"

n.c. not calculated. (1) denotes years in period 1975/76 to 1979/80. (2) denotes years in period 2005/6 to 2019/20.

TABLE 8.5

Present values per hectare of net social benefits from dairying, beef grazing and radiata pine plantations based on MOST LIKELY estimates of costs and prices and a discount rate of 4 percent

Management Area		FORESTRY A Rotation 15 years	FORESTRY A Rotation 20 years	FORESTRY B Rotation 30 years	FORESTRY B Rotation 35 years	FORESTRY B Rotation 40 years	FORESTRY C Rotation 30 years	FORESTRY C Rotation 35 years	FORESTRY C Rotation 40 years	Dairying A	Dairying B	Beef Grazing A	Beef Grazing B
Bega	(1)	n.c.	111	1834	2377	2350	2972	2925	2823	188	-608	490	116
	(2)	-99	111	2078	2622	2595	3130	3083	2981	188	-608	"	"
Bemboka	(1)	n.c.	-98	1614	2164	2150	2723	2683	2593	142	-633	"	"
	(2)	-285	-98	1826	2376	2362	2881	2841	2751	142	-633	"	"
Bondi	(1)	-85	740	2346	2951	2942	3796	3795	3697	7	-707	"	"
	(2)	460	740	2620	3226	3217	4006	4005	3906	7	-707	"	"
Burragate	(1)	-181	530	1586	2114	2097	2439	2404	2328	95	-658	"	"
	(2)	274	530	1832	2361	2343	2597	2562	2486	95	-658	"	"
Candelo	(1)	-507	162	1788	2330	2305	2887	2842	2744	167	-619	"	"
	(2)	-54	162	2034	2576	2550	3045	3000	2902	167	-619	"	"
Cobargo	(1)	n.c.	-164	2008	2647	2662	3667	3670	3581	131	-639	"	"
	(2)	-344	-164	2213	2852	2868	3876	3880	3790	131	-639	"	"
Lower Brogo	(1)	n.c.	-152	1714	2266	2248	2874	2830	2733	173	-616	"	"
	(2)	-333	-152	1918	2470	2452	3032	2988	2891	173	-616	"	"
Nungatta	(1)	4	841	2178	2779	2776	3512	3515	3429	28	-695	"	"
	(2)	550	841	2453	3055	3051	3721	3725	3639	28	-695	"	"
Pambula	(1)	-144	572	1753	2281	2255	2650	2608	2522	121	-644	"	"
	(2)	371	572	1999	2527	2502	2808	2766	2680	121	-644	"	"
Wyndham	(1)	-367	320	1659	2195	2175	2637	2597	2512	121	-644	"	"
	(2)	87	320	1905	2441	2422	2795	2755	2670	121	-644	"	"

n.c. not calculated. (1) denotes years in period 1975/76 to 1979/80. (2) denotes years in period 2005/6 to 2019/20.

SENSITIVITY TO CHANGES IN THE SOCIAL DISCOUNT RATE

In Chapter 3, it was pointed out that the most likely value of the social discount rate occurs somewhere between 4 and 6 percent. Therefore, because of the major impact that changes in the discount rate can exert on the present value criterion in forestry projects (McCarthy et al., 1969), it seemed desirable to evaluate the various alternatives at the lower and upper bounds of this range (4 and 6 percent) to assess whether there might be any change in the pattern of results. The results based on 6 percent are presented in Table 8.4 and on 4 percent, in Table 8.5.

An examination of the results shows that the pattern found for the most likely cost, price and yield levels and at a discount rate of 5 percent, remain largely unchanged. Nevertheless, some minor changes were apparent in the results for 4 percent discount.

The most significant feature at 4 percent is the extremely large response of the radiata pine alternatives. This is especially evident in the Forestry C strategy where increases in excess of $1,000 per hectare often occur. Although the same Management Areas were found to produce negative present values under the 20 year Forestry A strategy, the areas producing positive values were much higher at 4 percent discount rate.

Irrespective of the discount rate used, radiata pine plantations managed primarily for sawlogs (Forestry B and C) remain the most economic propositions at the most likely estimates of costs, prices and yields. The development of at least part of these areas for radiata pine plantations therefore warrants serious consideration.

SENSITIVITY TO CHANGES IN YIELDS

Yields could also be regarded as another area where uncertainty exists, particularly for the radiata pine strategies. However, provided the farmlands are properly prepared for planting, the yields predicted in the study can be confidently anticipated. The mean annual volume increment for Forestry B was 17.5 m^3 per hectare per annum for site index 24 plantations and about 20 m^3 per hectare per annum for site index 27 plantations. However, to allay any reservations regarding this point, yields were simulated for site index 21 regularly-thinned plantations managed under the same schedule as Forestry B based on Bega Management Area, and the present value per hectare calculated. Again using most likely costs and prices, an economic surplus was calculated ($1,054 per hectare) which compared more than favourably with the farming alternatives in the same locality. The mean annual volume increment for the 35-year rotation evaluated was 13.5 m^3 per hectare.

CONCLUSIONS

The results in this comparative analysis clearly established that radiata pine plantations hold considerable potential for the farming areas in the Lower South Coast Region irrespective of the assumptions relating to prices, costs and yields and regardless of the discount rate applied.

There was plenty of evidence available in the farm woodlots located in the Region which supported this view. In spite of generally poor management techniques, a site index of 21 metres was commonplace and emphasised one of the major attributes of radiata pine grown in drought-susceptible areas in the high rainfall zone of southern Australia - its ability to withstand long periods of drought. With proper management, particularly the application of fertilizer and site preparation, the average site index of the farmlands should be raised significantly.

While there is scope for a large plantation undertaking, the problem of its scale, its location and the strategies that would best fit the requirements of the project still need to be resolved. These questions can only be answered by constructing an economic model of wood production for the Region. This represents the main purpose of Part II of this study. The possibility of integrating forestry with farming must also be given serious consideration for, as Borough and Reilly (1976) showed, the economic trade-off from forestry to beef grazing need not be significant and it would improve the cash-flow situation of the project in its early stages of development. However further examination of this possibility must await the results of field trials now in progress.

CHAPTER 9

A REGIONAL MODEL OF WOOD PRODUCTION

OBJECTIVE AND SCOPE

In Part I of this investigation, it was found that some 130,000 hectares of farmland existed in the Region south of Cobargo, most of which would be economic for conversion to radiata pine plantations. At least 70,000 hectares of this were considered to be marginal for farming.

An economic model of wood production was developed for the Region primarily in order to establish the best way of integrating conversion of the farmland to pine plantations with other wood-producing activities in the Region. As indicated in Chapter 1, the model was based on a linear programming framework.

A basic model (designated R1) consisting of all of the productive indigenous forests in the Region was constructed initially. It excluded any consideration of farmland but the current proposal to convert about 40,000 hectares of indigenous forest to pine plantations in State Forests in the Bombala Plantation Working Circle in the south west of the Region was included. This Working Circle consists of Bondi, Coolangubra, Glenbog and Tantawanglo State Forests. Parts of Bondi, Coolangubra and Glenbog have already been planted.

In constructing this model, considerable notice was taken of opinion from local foresters and sawmillers that the hardwood sawlog resource would be largely cut out over much of the Region in 20 to 40 years' time. Therefore, there seemed to be a great deal of potential for progressively converting marginal farmland to softwood plantations in order to supplement future sawlog supplies from the Bombala Plantation Project on Crown land.

However, it was found in early computer runs of model R1 that the indigenous forests were capable of producing much more wood than originally was thought possible at least for the next 50 years, and therefore could satisfy most of the demands for sawlogs imposed on them. This meant in effect that the role of the softwood plantations would be confined more to satisfying specific demands such as:-

(i) the demand for sawlogs for a large softwood sawmill located in the Region, and

(ii) the demand for softwood pulpwood

rather than the deficit arising between Regional supply and demand. In the light of these results, it was necessary to reconsider the role of farmland in Regional wood supply.

Because, the farmland covers such an extensive area (130,000 hectares compared with about 45,000 hectares in the Bombala Plantation Working Circle), it would be capable of making an enormous impact on the Region's wood supply if unrestricted planting was permitted. It was also considered to be competitive with the Bombala Plantation Working Circle because of its favourable location to markets, particularly Sydney, its relatively high potential productivity and its lower cost of plantation establishment. For these reasons, the farmland must be regarded as an attractive alternative to the Bombala Plantation Working Circle.

A further model (designated R2) was therefore developed. It was based essentially on model R1 but assumed that the pine planting programme in the Bombala Plantation Working Circle would be discontinued from 1975/76 onwards with the farmland being planted instead. Thus, models R1 and R2 were treated as mutually exclusive proposals.

Therefore, the main aim of Part II of this investigation is to determine whether society is likely to be worse off economically by converting the farmland in the Region to pine plantations rather than eucalypt forest in the Bombala Plantation Working Circle. This was achieved by computing optimal solutions for each model and then comparing the present value of the net social benefits accruing to each model. This, of course, is an oversimplification to the problem, but it does highlight the major policy issue involved.

The analysis seems to be biased in favour of model R1 in two ways:-

(1) The social opportunity cost of land required for the Bombala Plantation Project, i.e. the present value of the net social benefits foregone in its best alternative use, did not take into consideration the intangible benefits associated with the native forests to be converted to softwood plantations. Therefore the present value of the net social benefits derived for the Bombala project will be over-estimated. These intangibles could not be evaluated in economic terms and consequently the opportunity cost of this land was based solely on wood production.

(2) The unplanted sections of Coolangubra and the western half of Bondi State Forests in the Bombala Plantation Working Circle were assumed to be reserved for conservation purposes (National or State Parks) and therefore were excluded from any form of wood production in model R2. This was because they represented the main centre of the conflict over the pine planting programme in the Bombala project. Consequently, model R2 did not have the same capability as model R1 to meet the sawlog quotas committed from Crown lands in the Bombala Forestry Sub-District and it was necessary to reduce the levels of the quotas specified in R1 in order to compute an optimal feasible solution in R2.

The present value of the net social benefits for the optimal solution to model R2 will be lower than that which would have been obtained had similar assumptions to model R1 been applied. It is reasonable to conclude that should similar present values be computed for the two models, then society would not suffer any significant loss in welfare by planting the farmland.

THEORETICAL CONCEPTS

The regional models of wood production employed in this study used essentially the same concepts as those in the comparative analysis. The present value of the net social benefits generated by wood production from the Region was the criterion by which welfare was measured, and the objective function of the economic planning model was to maximize the value of this criterion. Prices were assumed to be unaffected by changes in the level of wood production from the Region and costs incorporated the social opportunity costs appropriate to the various sources of capital used to finance reforestation activities. The estimation of net social benefits was based on the social benefits and costs attributable to each wood production strategy, measured "at stump".

All land, irrespective of ownership and capable of being utilized for wood production was considered to be eligible for incorporation in the planning models, provided that it had not already been set aside permanently and exclusively for other purposes or, in the case of the farming areas, provided that the areas were not so small or fragmented as to prohibit efficient investment in forestry.

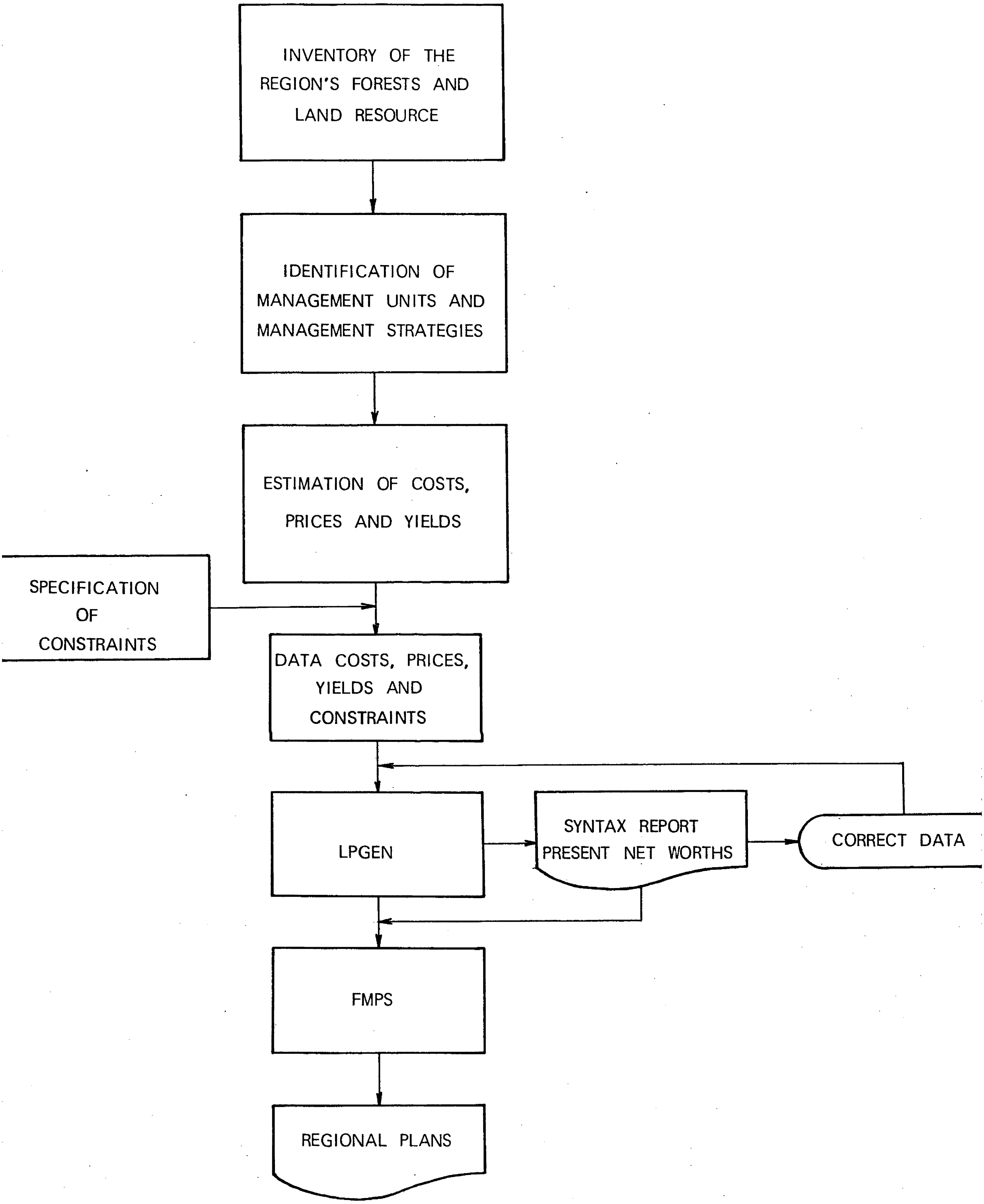


FIGURE 9.1 **Schematic representation of planning model for Lower South Coast**

THE REGIONAL MODEL - AN OUTLINE

The principles outlined in this section apply to both models R1 and R2. The basic model of forest production, R1, was developed by considering the regional system involved; decomposing the system into its basic elements; analysing these elements in detail; and using the results of these analyses to reconstitute the whole system into a large mathematical planning model.

The model finally adopted is shown diagramatically in Figure 9.1. Firstly, an inventory of the forest resource and an assessment of the capability of the farmlands for wood production were carried out. Secondly, using the information from the inventory, feasible wood production alternatives, or management strategies, were identified and then costs, prices and yields specified. Thirdly, resources and other factors expected to limit the supply of wood products from the Region were identified and, where relevant, were incorporated in the model. The future demand for wood products was also estimated and defined the upper limits to the output of these products from the Region at the prices assumed in the model. Fourthly, the data on costs, prices, yields and constraint names were used to prepare a linear programming matrix using a matrix generator, LPGEN, developed for the purpose.

LPGEN computed the present net worth values for each strategy and set up the coefficient matrix and objective function vector for input into the linear programming algorithm, in this case the commercial package, FMPS. Optimal solutions were then computed by FMPS. Each of these steps is briefly examined in the following discussion.

Inventory

The inventory of land and forests in the Region was carried out in two parts, one based on the farmlands and their capability for radiata pine plantations and the other based on the indigenous forest resource. The former was discussed in Chapter 2. The indigenous forests and farmlands were divided into relatively homogeneous units called Management Units.

Management Units

The individual Management Unit represented the basic decision element relevant to the model and was defined by the procedure outlined in the following.

A hierarchical pattern was used to subdivide land in the Region geographically. Firstly, four supply zones were identified and named according to the assumed primary objective of management:-

- a <u>Pulpwood Supply Zone</u>, located south of the Bega River, including the Tablelands;
- a <u>Mining Timber Supply Zone</u>, extending from Cobargo in the south to the northern boundary of the Region, but excluding the steeper areas in the vicinity of the escarpment where mining timber operations would not be feasible;
- a <u>Sawlog Supply Zone</u>, located west of the Mining Timber Supply Zone and north of approximately the Brogo River;
- a <u>Transition Supply Zone</u>, situated between the Mining Timber and Sawlog Supply Zones in the north and Pulpwood Supply Zone to its south.

Pulpwood logging was also assumed to be permitted in the Mining Timber and Sawlog Supply Zones where it was technically feasible and where it assisted in the silvicultural treatment of the forests, and provided that it did not conflict with environmental considerations. The Transition Supply Zone embraced the area where joint production of pulpwood, sawlogs and mining timber was considered feasible.

The above zonation was based on existing and proposed plans for wood production and on an independent assessment of economic factors influencing wood supply, particularly transportation costs, roading requirements and market location.

Each Supply Zone was subdivided further into Management Areas according to land tenure, location and, to a lesser degree, homogeneity with respect to topography, forest type and structure, geology, soils, climate; and, in the case of the farmlands, according to their potential productivity (i.e., their site index) for radiata pine plantations.

Management Areas were then broken down further into Management Units, the basic land units for management purposes. Management Units in the eucalypt forests were classified on the basis of broad forest types, slope and the potential productivity of the site in terms of wood production, using mature stand height and stand structure, supplemented by geology and rainfall, as indicators. Management Areas in the farming districts, however, were not subdivided further. Instead the weighted average site index estimated for each Management Area in Chapter 2 was adopted.

While Management Units provide the final stage in the geographic subdivision of the Region, their exact spatial location within each Management Area was not defined because of the inventory procedure used. Nevertheless, the properties used to define their extent and characteristics were such as to enable their identification in field practice.

Management Areas resolve the main locational and, to a lesser extent, administrative aspects of the planning model whereas Management Units were considered to fulfil a three-fold purpose: firstly, to provide an index of land capability for wood production; secondly, to indicate the silvicultural condition of the indigenous forests; and thirdly, to provide a suitable basis for identification in the field.

Management Strategies

As pointed out in Chapter 1, two planning horizons were adopted, one consisting of the linear programming planning horizon of 50 years, and the other the infinite investment planning horizon. The linear programming planning horizon represents the limit of time during which constraints were identified explicitly in the model. The planning horizon was split into ten 5-year planning periods. Operations performed in each year of a planning period were assumed to be identical, changing instantaneously at the end of each period to the new set of operations specified for the next planning period.

A management strategy represented a predefined sequence of operations over time for a particular Management Unit. For each Management Unit, a number of feasible management strategies existed which could be implemented. Different silvicultural systems, regeneration techniques and timing of such operations may be used in defining different strategies. The silvicultural system and regeneration technique adopted were largely determined by the aims of management. A wide range of silvicultural systems were thus appropriate for some Management Units whereas a more restrictive set were more appropriate for others. The set of possible strategies ranged from those based on complete clearfelling, through partial cutting systems such as group selection, to individual tree selection based on a cutting diameter limit. Regeneration techniques ranged from natural seeding and coppicing from stumps or lignotubers through to complete planting of the site.

The timing of the same sequence of logging and silvicultural operations were varied by specifying the planning period in which these operations were to be carried out.

Rotation length was also varied where it was considered pertinent to do so particularly in the Pulpwood Supply Zone where integration of the farmlands was likely to have the greatest impact.

Production Costs and Yield Data

Data on production costs and yields were expressed on a per hectare basis and their derivation is examined in detail in Chapter 11.

As a general rule, separate cost budgets were developed for each type of management strategy with variations as appropriate for each Management Unit. Costs included direct and indirect field costs, administrative overhead and social opportunity costs appropriate to the different sources of funds referred to previously in Chapters 3 and 4.

The relatively large number of quite distinct productivity groupings identified in the indigenous forests and the application of both even-aged and selection management systems necessitated the use of a variety of methods of yield estimation. Simulation models were used wherever possible but where they were not available, standard yield tables were employed or were developed specifically for the model.

Stumpage Prices

Again, as in the comparative study, it was necessary to examine the markets in which the products were to be sold and to calculate shadow prices for stumpage using the residual value method referred to in Chapters 5 and 6.

Constraints

Four broad groups of constraints were identified: those relating to area, those affecting wood supply, those defined by the demand for wood products and those relating to limitations on financial resources.

The Management Unit, or Management Area in the case of farmland, constituted the fundamental unit of land for the specification of Management Strategies. In order to ensure that each such Unit or Area was allocated to at least one Strategy, it was necessary to constrain the areas cut under each set of Strategies to equal in sum the total area of the Unit or Area except in the case of land used for radiata pine plantations where the available area mostly defined the upper limit.

Two industry commitment constraints were recognized: (1) those based on existing commitments under agreements with the Crown and (2) those based on future industrial development. The first relates to the minimum levels of pulpwood, sawlogs and mining timber that the Forestry Commission is committed to supply to industry from Crown lands in the Region. The second relates to the quantities of sawlogs and pulpwood that must be supplied under assumptions involving structural change to industry in the model. With respect to pulpwood, it was assumed that the chipmill at Edrom would represent the only outlet for pulpwood until 1994/95. In the following year, a pulpmill requiring a larger volume of raw material was assumed to start production. The present structure of the hardwood sawmilling industry was assumed to remain until 1995/96 when a small number of large mills would replace the original units. Sawlog production from radiata pine plantations was assumed to be processed through a large sawmill, one located at Bombala in the case of model R1 and the other located at Bega in the case of model R2. These mills would start production in 1995/96 on one-shift per day production and in 2005/6, switch to two-shifts per day.

The level of intensity of management of a particular Management Unit is dependent not only on its physical and locational characteristics and, in the case of forested land, the forest type, but also on the relative availability of labour, capital and transferable inputs which can be applied. Labour and transferable inputs were not considered to be limiting factors and therefore were not incorporated as constraints. It was argued that because unemployment has consistently exceeded job vacancies in the Region, a pool of labour would always be available; in the case of transferable inputs, because their prices were assumed to be unaffected by any likely changes in land use, any impact on their supply would not be significant.

Thus, capital (i.e., financial resources) was treated as the sole limiting factor. Of the three sources of funds employed in financing the Commission's operations (Consolidated Revenue, Trust and Loan Funds), only loan capital was regarded as relevant, since it represented the major source of funds for reforestation activities and capital works. Because the extent and intensity of these works in any one year is dependent principally on the availability of loan funds, the aggregate expenditure on any set of production strategies cannot exceed the amount appropriated from this source.

The Region plays an important role in the wood supply situation in New South Wales, and because of its proximity to the large markets of Sydney, Port Kembla-Wollongong, Canberra and Melbourne, it seems inevitable that it will have to maintain production levels at least at the level of the market that it currently supplies. Two demand constraints were required for each major product: one representing the minimum levels of wood products required by existing and future industry, and the other, representing maximum levels based on anticipated growth in demand.

Matrix Generation

As indicated previously, a program (LPGEN) was developed which computed the present net worth and land expectation values (i.e., the present value of net social benefits over an infinite time period) for each management strategy and Management Unit and set up the coefficient matrix and objective function vector for FMPS. A description of this program is provided in Appendix 9.1. (page A81).

Separate present net worths were calculated each time a price, cost or yield change was indicated. The land expectations values were calculated by adding the present net worth for a specific strategy extending over at least the length of the planning horizon of 50 years and to the end of the initial investment period (rotation in the case of even-aged stands, and cutting cycle in the case of uneven-aged stands) to the terminal values of the land appropriately discounted. The terminal value was either calculated manually and coded in with the other data or it was computed by selecting the maximum present value of future benefits and costs at the end of the period covered by the management strategy specified, from all strategies designated for a particular Management Unit. Where the terminal value was less than zero, a zero value was substituted. This was based on the assumption that wood production would virtually cease and the revenues so derived would equal annual protection and other maintenance costs. Terminal values were based solely on even-aged management strategies because of the greater reliability of the costs and yield data estimated for these strategies.

The interest rate adopted for discounting was again 5 percent and was based on the analysis in Chapter 3.

SPECIFICATION OF CONSTRAINTS

Constraints referred to earlier in this Chapter were assumed to apply only to the 50-year planning horizon adopted. They can change from one planning period to another, with the changes occurring instantaneously at the beginning of the nominated planning period.

Each type of constraint was given a code name, each ending where required with a single digit signifying the planning period to which it applies; that is, if planning period 1975/76 to 1979/80 was designated, the relevant digit would be 0; 1980/81 to 1985/86, the digit is 1, and so on as for the management strategies.

AREA CONSTRAINTS

The Management Unit was adopted as the basic unit for constraining the area of land to be used for wood production. The area data on which constraint values were based are presented in Table 2.4 for cleared land in Management Areas in the farming areas and in Appendix 10.4 for native forest Management Areas and Management Units.

WOOD SUPPLY CONSTRAINTS

1. Pulpwood Supply from Native Forests on Crown Land

The major constraint on the supply of pulpwood from Crown lands was based on the Pulpwood Agreement between Harris-Daishowa (Aust) Pty. Ltd. and the New South Wales Government. It was designated PULPEC n and denoted the maximum quantity of pulpwood to be supplied from native forests in planning period n. The value adopted for all planning periods was 580,000 m^3 and was based on the commitment agreed to by the New South Wales Government. The agreement was signed in 1968 and because operations did not commence until 1970/71, it was assumed that only five years of the 20-years agreement period had elapsed by the start of the planning horizon, 1975/76. Since the ultimate objective is to manage these forests for sustained yield production it was also assumed that 580,000 m^3 would apply to all planning periods.

The supply area covered by the agreement includes State Forests located on the Tablelands and in the coastal area south of the Bega River. However, there has also been an understanding that some of the State Forests located in the Bega Sub-District would also be managed for pulpwood production.

A recent public inquiry into the management of State Forests in the areas defined as Mumbulla and Murrah Management Areas in this study resulted in two sections being declared National Park. The remaining areas now seem likely to be available for pulpwood logging provided operations are properly regulated.

During planning periods 0 to 3 in model R1, a significant share of the total commitment will be supplied from plantation clearing in the Bombala Plantation Working Circle (or Project). The Forestry Commission proposes to plant about 40,000 ha with radiata pine in the Working Circle at a rate of at least 1,600 ha per annum and based on estimates reported by Davies et al. (1974) about 200,000 m^3 of pulpwood would be available from this source during the conversion phase.

It was estimated that by 1975/76 the area remaining to be planted totalled 44,500 ha of which 9,200 ha were located in Bondi Management Area, 6,500 ha in Coolangubra Management Area, 10,000 ha in each of Glenbog and Tantawanglo Management Areas and 8,800 ha in White Rock Management Area.

A minimum planting rate constraint, PLANTB n, was incorporated in the model and was set at 1,600 ha in planning periods 0 to 2 and 800 ha in planning period 3. The latter constraint was based on planting 40,000 ha by 1994/95. The same constraints were applied to model R2.

A pulpwood supply constraint was also specified for the Bombala Working Circle. It was designated HPULPT n, and denotes the minimum level of pulpwood production from this source during the conversion period from planning periods 0 to 3. Initially the value set for periods 0 to 2 was 150,000 m^3 and for planning period 3, 50,000 m^3. This constraint was later freed in model R1 when it was found that it did not play a major part in the computation of the optimal solution, PLANTB n being the more significant constraint. It was not applied at all in model R2.

In calculating pulpwood yields from the Bombala Plantation Working Circle in model R1, adjustments were made for the additional production from road clearing associated with plantation establishment. The net area available for planting in each Management Area was also reduced by about 20 percent, partly for this factor but also partly to allow for the retention of native forest for environmental purposes.

The net areas available for planting in the farmland Management Areas in model R2 were estimated by reducing the gross areas from Chapter 2 by ten percent to allow for roading.

Minimum pulpwood supply constraints were also specified for other parts of the Pulpwood and Transition Supply Zones:-

HPULPA n. This consists of East Boyd, Naghi, Yurammie-Burragate and Nullica-Bimmil Management Areas and the value was set at 100,000 m^3 per annum initially.

HPULPB n. This consists of Towamba, Yambulla North and South Management Areas which are located on the granite hill country abutting the Tablelands. A value of 100,000 m^3 per annum was also adopted for this constraint.

HPULPC n. This consists of Brown Mountain, Mumbulla and Murrah Management Areas and 50,000 m^3 per annum was specified.

The purpose of these three constraints was to spread logging operations over the Pulpwood and Transition Supply Zones as evenly as possible during the planning horizon in order to reduce undesirable environmental impacts to a minimum and to provide an effective protection system against wildfire over the whole area as quickly as possible. They were applied to both models R1 and R2.

2. Constraints on Pulpwood Production from Radiata Pine Plantations

This constraint was designated PULPRF n where PULPRF denotes the minimum level of pulpwood required from radiata pine plantations in planning period n.

There was no need to apply this constraint in planning periods 0 to 3 since the chipmill would be able to absorb any available supplies and in any event the output from radiata pine plantations was unlikely to be significant.

However, when the pulpmill starts up in planning period 4, at least one third of its pulpwood requirements was assumed to originate from plantations in both models. This was based on the ratio of softwood : eucalypt pulpwood reported to be used by APM Ltd's kraft pulpmill at Traralgon in the early 1970's.

The value of this constraint from planning period 4 onwards was therefore estimated to be 400,000 m^3 since just over 1,400,000 m^3 of softwood pulpwood or 1,260,000 m^3 of eucalypt pulpwood would be required to meet the pulpmill's requirement at its assumed capacity of 263,000 ADMT per annum. An upper limit of 700,000 m^3 or 50 percent of the equivalent volume of softwood pulpwood was also imposed.

3. Constraints on Pulpwood Production from Privately-Owned Native Forests

The name given to this constraint was PULPEP n and denotes the minimum commitment of pulpwood from private land in planning period n.

A minimum value of 50,000 m^3 per annum was adopted for all planning periods and was based on the production from private property reported by the Forestry Commission in its Annual Reports and on the estimated minimum sustainable yield that could be supported from this source.

TABLE 9.1

Details of sawlog supply area constraints

Code Name	Supply Area	Management Areas
QSAWBB	Batemans Bay Sub-District excluding North and South Kioloa Management Areas	Buckenbowra, Currowan, Mogo, Quartpot and Yadboro
QSAWBE	Bega Sub-District	Badja, Brown Mountain, Mumbulla, Murrabrine, Murrah, Upper Tuross and Yourie
QSAWBM	Bombala Sub-District	Bondi, Coolangubra, Glenbog, Tantawanglo and White Rock
QSAWBO	Bodalla Management Area	Bodalla
QSAWED	Eden Sub-District	East Boyd, Naghi, Nullica-Bimmil, Towamba, Wallagoot, Yambulla North, Yambulla South and Yurammie-Burragate
QSAWKI	Kioloa Management Group	North and South Kioloa
QSAWNA	Narooma Sub-District excluding Bodalla Management Area	Araluen, Belimbla, Belowra Burra Creek, Deua, Moruya, Nerrigundah, Tinpot and Wadbillaga

4. Constraints on Sawlog Production from Native Forests on Crown Lands

This constraint was designated QSAWxx n where QSAW denotes the minimum quantity of quota mill logs to be supplied per annum, xx denotes the supply area from which quota mill logs are committed and n denotes the planning period as previously.

Seven supply area constraints were identified and details of these are presented in Table 9.1. Under the mill log quota system, the Forestry Commission guarantees to supply sawmills holding a Crown licence with an annual volume of quota logs from Crown lands for a specified period. Parcel sales which are temporary commitments by the Commission to supply sawlogs over a shorter period are also taken into consideration. These are usually associated with salvage operations prior to silvicultural treatment or following wild-fires.

The quota system is typically based on the sustainable yield from a Sub-District for areas not under a formal management plan and usually over a period of 40 years, or from an area for which such plan is available.

Entitlements to quotas and parcel sales are maintained under constant review by the Forestry Commission both with respect to the satisfactory operation of the sawmill and more up-to-date information on the supply situation.

The values on which each of the seven constraints by planning periods were based, are presented in Table 9.2.

TABLE 9.2

Minimum volume of sawlogs committed to hardwood sawmills from indigenous forests on Crown lands

Constraint Name	Minimum volume per annum (m^3) in planning periods		
	0 to 3	4 to 6	7+
QSAWBB	25,000	25,000	Zero
QSAWBE	25,000	25,000	Zero
QSAWBM	35,000	Zero	Zero
QSAWBO	3,900	3,900	3,900
QSAWED	30,000	30,000	Zero
QSAWKI	22,000	22,000	22,000
QSAWNA	30,000	30,000	Zero

These volumes were based on entitlements operating in 1972/73. However, they were not regarded as binding on the two models. Therefore, where there was sufficient reason (infeasibility, considerable slack or high shadow prices), the values were modified accordingly.

QSAWBO and QSAWKI were the only constraints based on sustained yields from formal management plans. The values for the other constraints, other than QSAWBM, were based on logging the available volume of quota sawlogs over 40 years, the period normally used by the Forestry Commission for determining the allowable cut. Values for planning periods 7, 8 and 9 were then set at zero.

QSAWBM, the constraint applied to the Bombala Sub-District, presented some difficulty in its valuation. In model R1, most of the commitment will originate from salvage operations associated with plantation clearing in the Bombala Plantation Working Circle. Thus nearly all available timber would be removed by planning period 3 when planting was assumed to terminate and thereafter only a small amount would be sustained from the unplantable, steeper areas in Glenbog and Tantawanglo Management Areas. In model R2, logging was excluded from the unplanted sections of Bondi Crown and Coolangubra Management Areas for reasons given in the introduction to this Chapter, and therefore the lower limits to QSAWBM had to be reduced in order to achieve feasible solutions.

The values finally settled on after some trial and error are presented in Table 9.3.

TABLE 9.3

Upper and lower limits for quota sawlog constraints for indigenous forests on Crown lands

Constraint Name	Planning Period	Volume per annum (m^3) Model R1	Model R2
QSAWBB	0 to 9	25,000 to 30,000	25,000 to 30,000
QSAWBE	0 to 9	35,000 to 40,000	35,000 to 40,000
QSAWBM	0 to 2	25,000 to 40,000	20,000 to 40,000
	3	20,000 to 30,000	20,000 to 30,000
	4 to 9	1,800 to 3,600	4,000 to 8,000
QSAWBO	0 to 9	7,500 to 9,000	7,500 to 9,000
QSAWED	0 to 7	35,000 to 45,000	35,000 to 45,000
	8 to 9	3,000 to 5,000	3,000 to 5,000
QSAWKI	0 to 9	52,000 to 60,000	52,000 to 60,000
QSAWNA	0 to 9	45,000 to 55,000	45,000 to 55,000

5. Constraints on Sawlog Production from Radiata Pine Plantations

This constraint was designated RLOGBM n in model R1 and RLOGBE in model R2 where RLOGBM and RLOGBE denote the minimum level of sawlogs required from new radiata pine plantations in planning period n by the hypothetical sawmill located at Bombala and Bega respectively.

Production from plantations in both models was assumed not to occur until planning period 4 when the sawmill will start up. The minimum levels adopted for this constraint were based on 101,000 m^3 per annum in planning periods 4 and 5 and 202,000 m^3 per annum in planning periods 6 to 9. These are the production levels on which stumpage prices for radiata pine sawlogs were based in the study. The actual values specified were equal to 80 percent of these capacity levels and provide for sawlog production from plantations established in the Bombala Plantation Working Circle prior to planning period 0 and from plantations established by Kapunda Development Co. Pty. Ltd. Thus for planning periods 0 to 3, the value adopted was zero; for periods 4 and 5, 80,000 m^3; and for periods 6 to 9, 160,000 m^3 per annum.

Upper limits were also specified - 200,000 m^3 in periods 4 and 5 and 300,000 m^3 in periods 6 to 9. These are well within the capacity of most large softwood sawmills in North America and were based on the possibility of operating the mill on 2 shifts per day in planning periods 4 and 5 and on 3 shifts per day in planning periods 6 to 9.

DEMAND CONSTRAINTS

The upper limit to the supply of wood products from the Region will be determined by the anticipated future demand for these commodities. However, because of data limitations it was not possible to describe existing markets in terms of an econometric model which could be used to predict future demand.

The only realistic alternative was to base such forecasts on the level of industrial activity anticipated in the model over the planning horizon assumed and where possible to adjust these estimates for market growth based on changing population and other factors.

1. Demand for Pulpwood

The name given to this constraint was DPULP n and it was assumed to express the upper limit to the demand for pulpwood in planning period n.

It was based on the requirements of (a) the chipmill until planning period 3 and (b) thereafter the bleached kraft pulpmill.

The export target sought by the chipmill is about 1,000,000 tonnes of chips per annum of which between 100,000 and 150,000 tonnes will be derived from sawmill residue in the Region, 100,000 tonnes from Gippsland Paper Pulp Pty. Ltd. consisting of sawmillers operating in the East Gippsland region of Victoria, 580,000 m^3 from Crown lands under the Pulpwood Agreement with the New South Wales Forestry Commission and the balance of about 190,000 m^3 from privately-owned native forests or radiata pine plantations in the Region. Thus an upper limit of

700,000 m^3 per annum was adopted in planning periods 0 to 3 and comprised production from the latter two forest sources (i.e., the Pulpwood Agreement supply area and privately-owned native forests or radiata pine plantations). A lower limit of 600,000 m^3 was also specified during these periods.

In planning periods 4 to 9, the maximum softwood requirements of 1,430,000 m^3 per annum needed to support the bleached kraft pulpmill at its design capacity was adopted. No adjustment was made for sawmill residues since it was considered that the pulpmill could easily handle any additional supplies from this source.

A lower limit of 1,170,000 m^3 was also specified by deducting the anticipated volume of sawmill residues to be supplied to the pulpmill (60,000 m^3 from the radiata pine sawmill and 200,000 m^3 from hardwood sawmills).

2. <u>Demand for Mining Timber</u>

This constraint was designated DMINT n which expresses the maximum requirements of mining timber to be produced from the Region in planning period n.

The Forestry Commission (unpub. data) has estimated that the South Coast coal fields may require about 100,000 m^3 of mining timber by 1979/80 of which at least 50 percent would have to be supplied from the Region based on production figures in recent years from areas supplying the coal mines. Between 30,000 and 35,000 m^3 have been produced annually in recent years, however, and there was a noticeable decrease in 1975/76.

The constraint values adopted have taken into account the possibility of anticipated demand not being achieved. A range rather than a single value was therefore assumed with the lower limit assumed to be 30,000 m^3 per annum for all planning periods based on recent experience and an upper limit of 45,000 m^3 which was 50 percent higher than the lower limit. No growth was provided for and it was decided to disregard the Commission's forecasts which, in view of recent trends, now seem to be too high.

3. Demand for Sawlogs

This constraint was designated DSAW n where DSAW denotes the maximum volume of sawlogs required annually from the Region in planning period n.

Because of the lack of data, it was not possible to formulate a mathematical model representing demand from the Region and therefore a range of values was adopted rather than a single upper limit.

The lower and upper limits for this constraint are presented in Table 9.4.

TABLE 9.4

Lower and upper limits adopted for the demand constraint for sawlogs (DSAW) from the Region

Planning Period	Volume of sawlogs (m^3 per annum)	
	Lower limit	Upper limit
0	250,000	350,000
1	250,000	368,000
2	300,000	387,000
3	300,000	406,000
4	400,000	427,000
5	400,000	449,000
6	400,000	472,000
7	400,000	496,000
8	400,000	521,000
9	400,000	548,000

The lower limits were based on sawlog production from the South Coast and South East Forestry Districts. During the 10-year period to 1972/73, annual production rose slowly from about 330,000 m^3 gross to 380,000 m^3 gross, averaging about 350,000 m^3 gross. Of this, about 75 percent was produced in the Region itself, i.e. about 265,000 m^3. Therefore in periods 0 and 1, a minimum of 250,000 m^3 per annum was specified rising to 300,000 m^3 per annum in planning periods 2 and 3. In planning period 4, sawlog requirements of 100,000 m^3 per annum for the large softwood sawmill which was then assumed to commence operations was also included, raising the lower limit in planning period 4 to 400,000 m^3 per annum. This was maintained at this level in all subsequent planning periods and was considered to reflect the minimum volume of sawlogs required to sustain a viable industry during this period.

The upper limits were based on 100 percent of the average production per annum for the 10-year period to 1972/73 which was adopted in planning period 0, plus growth in demand at 0.7 percent per annum which is equal to the rate of growth in sawlog consumption forecast by the Bureau of Agricultural Economics (1977) for the period 1976 to 2020.

FINANCIAL CONSTRAINTS

The Forestry Commission was assumed to be solely responsible for the administration and financing of forestry activity in the Region. However, although the Commission derives funds from three main sources

(Consolidated Revenue, Trust or Section 13 Special Deposit Account and Loan), it was assumed that only loan funds would be limiting. This is an over-simplification but in view of the relatively high level of revenue earned by the Commission from the Region, mostly from timber sales, this assumption seemed reasonable. Without loan funds, the Commission cannot undertake new forestry development projects. Section 13 funds are used to defray expenditure mainly of an annually recurring nature such as protection, marketing, maintenance of capital works and some field overheads while consolidated revenue funds are used to pay salaries and other administrative costs, and ultimately interest and redemption on outstanding loans.

Loan funds are supplied from two sources - one from the normal State loan allocation which is raised by the Commonwealth Government on behalf of the States under the Financial Agreement of 1927 and the other is provided by the Commonwealth Government under the Softwood Forestry Agreements Acts of 1967, 1976 and 1977 which are treated as loans outside the Financial Agreement. A new Softwood Agreement is currently under consideration but it is understood that it will be restricted to maintenance of new softwood plantations financed by the Commonwealth under previous Agreements with possible extension to the purchase of privately-owned land.

The Softwood Forestry Agreements have played a significant part in financing establishment and maintenance of new softwood plantations throughout Australia. During the period of the second Agreement from 1971/72 to 1975/76, the Commonwealth financed the establishment of an additional 3,938 ha per annum out of a total nominal programme of 7,491 ha per annum in New South Wales.

In the period 1962/63 to 1972/73, there was a dramatic rise in the availability of loan funds for the State's reforestation programme, due primarily to the influence of Softwood Forestry Agreement funds. However, while continuation of past rates of growth from this source is unlikely, State loan allocations should continue to rise at about the rate of 4 percent experienced over this period.

The loan fund constraint was designated LOAN n where LOAN denotes the upper limit of available loan funds annually and n denotes the planning period in which the constraint applies. In determining the upper limit to the availability of loan funds, it was necessary to separate total loan funds into those applied to softwood plantations and those applied to native forests.

In 1971/72, the only year for which a detailed dissection of the Region's expenditure was available to the author, approximately $580,000 of loan funds were used of which about half was spent on softwood plantations mostly in the Bombala Plantation Working Circle, and half on native forest regeneration treatment and necessary capital works.

Maximum requirements in planning period 0 were estimated to be $850,000. This was based on the loan allocation of $580,000 to the Region in 1971/72 adjusted for (a) the natural increase in State Loan funds of 4 percent per annum, plus (b) the increased expenditure associated with expanding the planting programme in the Bombala Plantation Working Circle from 1,100 ha approximately in 1971/72 to at least 1,600 ha per annum by the beginning of planning period 0. In planning periods 1 to 3 it was assumed to be equal to $850,000 plus 4 percent increase per annum, and thereafter remaining constant. The values adopted, excluding and including the social opportunity cost of the loan funds at 5 percent (i.e., \$2.73) are presented in Table 9.5.

TABLE 9.5

Upper limits for loan funds for financing forestry works in the Lower South Coast Region

Planning Period	Excluding Social Opportunity Cost:	Including Social Opportunity Cost:
0	\$ 850,000	\$2,320,000
1	\$ 1,034,000	\$2,800,000
2	\$ 1,258,000	\$3,400,000
3 to 9	\$ 1,530,000	\$4,200,000

Loan funds were assumed to be applied during the initial development period of each management strategy only, i.e. cutting cycle, rotation. Thereafter it was assumed the Commission would rely solely on Trust or Section 13 funds to finance its operations; i.e., the Commission will become self-financing.

In addition to an upper limit to the availability of loan funds for the whole Region, provision was made for minimum allocations for each Forestry Sub-District. These were designated LOANxx n where LOANxx denotes the minimum allocation of loan funds that must be spent in Sub-District xx in planning period n.

However, although these constraints were included in both models, at no time were any limits applied. Instead, the model was left to allocate loan funds by Sub-Districts.

The Linear Programming Matrix

The objective function involved the maximization of the present value of the net social benefits from wood production both spatially within the Region and over time. This may be written as follows:-

$$\max \sum_{k=1}^{N} \sum_{a=1}^{a_k} X_{ka} P_{ka}$$

where X_{ka} denotes the area (in hectares) of Management Unit k managed according to management strategy a;

P_{ka} denotes the present value of net social benefits per hectare added by applying strategy a to Management Unit k;

N denotes the number of Management Units available for forest management;

a_k denotes the number of management strategies which can be applied to Management Unit k.

One set of constraints expresses the fact that the area of a particular Management Unit subjected to forest management must be equal to its available area. That is,

$$\text{for all } k: \sum_{a=1}^{a_k} X_{ka} = A_k$$

where A_k denotes the area of Management Unit k in hectares. This was applied to all Management Units in both models except in the case of Management Units designated for radiata pine plantations where the available area, A_k was specified as an upper limit.

The financial constraint on loan funds is expressed as follows:-

(a) For the Region as a whole, the sum of loan capital spent on all eligible Management Units must not exceed the total amount of loan funds available for the Region. That is,

$$\sum_{k=1}^{N} \sum_{a=1}^{a_k} X_{ka} c_{kat} \leqslant C_t$$

where c_{kat} denotes the amount of loan funds incurred in managing one hectare of Management Unit k according to management strategy a in planning period t;

and C_t denotes the total amount of loan funds available for the whole Region in planning period t.

The constraint for wood supply commitments to industry expresses the fact that certain specified levels of wood products must be produced from certain areas within the Region over the 50 year planning horizon. That is,

$$V_{mti}^{(l)} \leqslant \sum_{k=1}^{P} \sum_{a=1}^{a_k} X_{kap}\, v_{kati} \leqslant V_{mti}^{(u)}$$

where X_{kap} denotes the area of Management Unit k managed according to management strategy a in area p;

P denotes the number of Management Units available for wood production in area m;

v_{kati} denotes the volume of product i harvested under strategy a from one hectare of Management Unit k in planning period t;

and $V_{mti}^{(l)}$ and $V_{mti}^{(u)}$ denote the lower (l) and upper (u) bounds for the total volume of product i committed to industry from area m in planning period t.

Another important constraint relates to the demand for wood products harvested from the Region. It means that production of any particular commodity must be within the limits prescribed for the Region. That is,

$$D_{ti}^{(l)} \leqslant \sum_{k=1}^{N} \sum_{a=1}^{a_k} X_{ka} \, v_{kati} \leqslant D_{ti}^{(u)}$$

where $D_{ti}^{(l)}$ and $D_{ti}^{(u)}$ denote the lower (l) and upper (u) bounds for the volume of each product i which it is estimated would be demanded from the Region in planning period t, and the other symbols are as previously defined.

The above model was solved by means of the Functional Mathematical Programming System, FMPS, (Bonner and Moore Assoc. Inc., 1975) using the UNIVAC 1108 computer at the Australian National University.

There is nothing novel in the application of linear programming to the solution of forest planning problems. It is similar in nature to the model used by Clutter et al.(1968), Navon (1971) and Weir (1972).

All of these studies and many others have played an important hand in extending the use of, and improving the value of, linear programming in the solution of a wide range of forestry problems. However none have attempted to use the principles of cost-benefit analysis in valuing the inputs and outputs of the various timber production strategies incorporated in a linear programming framework. Nor has there been any attempt to consider a wide range of strategies in the management of an irregular eucalypt forest in the planning model. This is essentially what makes this model different from other models; the system on which it is modelled is similar in many respects to Timber RAM (Navon, 1971) but the valuation of benefits and costs and the diversity of the forest types and strategies distinguishes it from other models.

CHAPTER 10

INVENTORY OF INDIGENOUS FORESTS

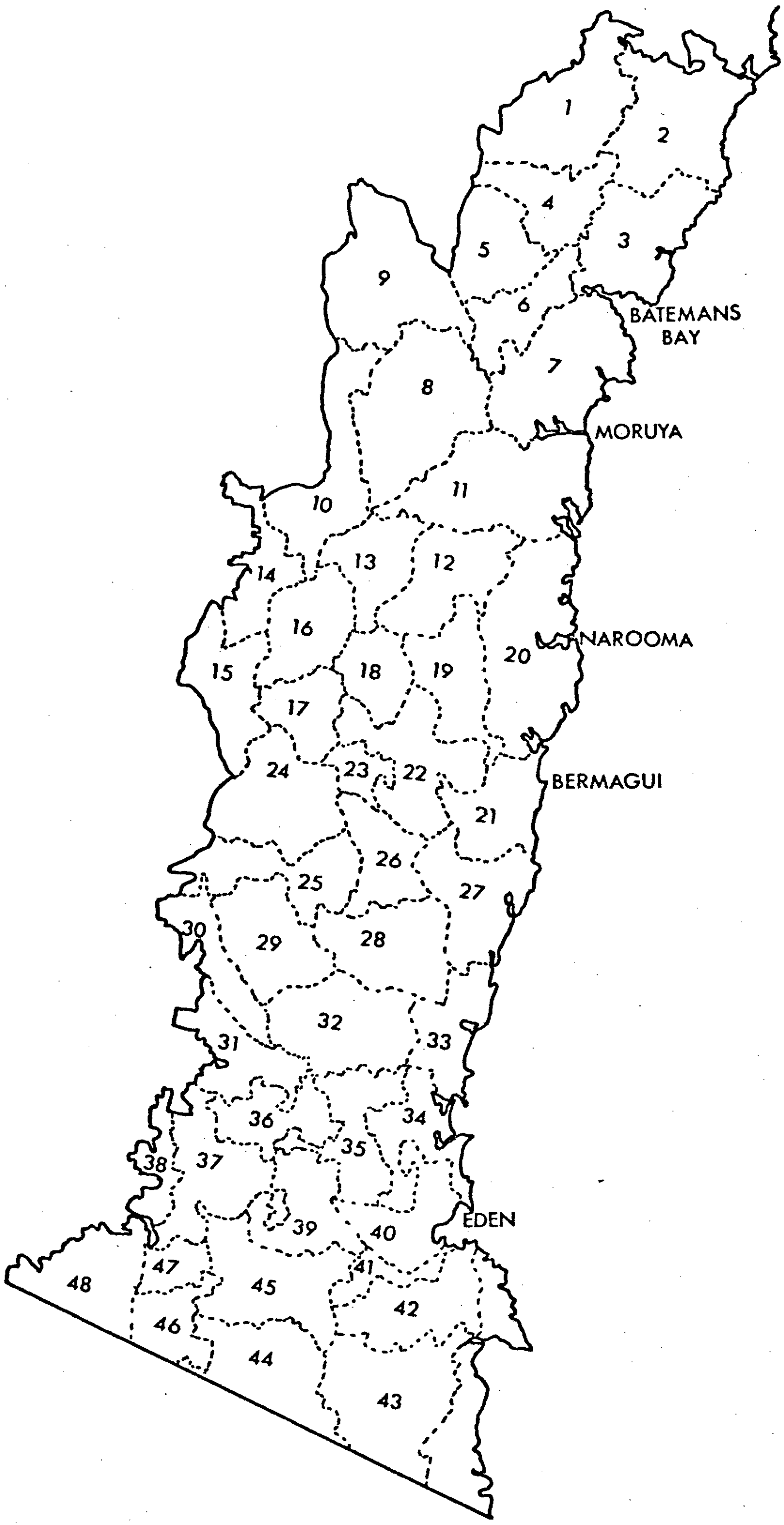
INTRODUCTION

Because of the size and complexity of the indigenous forests, it was essential to limit the investigation to those parameters likely to make the greatest impact on the present value criterion. A large number of simulations of possible strategies were run during the early stages of development of the planning model to identify these parameters. The level of merchantable growing stock was found to be a more significant factor than growth and therefore considerable effort was directed at obtaining the best possible inventory of the indigenous forest resource.

INVENTORY

Identification of Management Units

A total of 22 Management Areas was defined in the Pulpwood Supply Zone, 7 in the Transition Supply Zone, 19 in the Mining Timber Supply Zone and 15 in the Sawlog Supply Zone. The location of these Management Areas is



MANAGEMENT AREAS

1 Yadboro
2 North Kioloa C & P
3 South Kioloa C & P
4 Currowan C & P
5 Buckenbowra C & P
6 Quartpot C & P
7 Mogo C & P
8 Burra Creek C & P
9 Araluen C & P
10 Deua
11 Moruya C & P
12 Nerrigundah
13 Belimbla
14 Badja
15 Upper Tuross C & P
16 Belowra C & P
17 Yourie
18 Wadbillaga
19 Tinpot C & P
20 Bodalla C & P
21 Murrah C & P
22 Cobargo
23 Murrabrine
24 Upper Brogo
25 Brown Mountain
26 Lower Brogo
27 Mumbulla C & P
28 Bega
29 Bemboka
30 Glenbog
31 Tantawanglo
32 Candelo
33 Wallagoot
34 Pambula
35 Yurammie-Burragate
36 Wyndham
37 Towamba
38 Coolangubra
39 Burragate
40 Nullica-Bimmil
41 Lower Towamba
42 East Boyd
43 Naghi
44 Yambulla South
45 Yambulla North
46 Nungatta
47 White Rock
48 Bondi

FIGURE 10.1 Management Areas in the Lower South Coast Region shown in Figure 10.1. The gross area of each, subdivided into broad tenure classes, is provided in Appendix 10.1 (page A97).

The exotic pine plantations (almost totally planted to radiata pine) at Bondi, Coolangubra and Glenbog Management Areas represent the main non-indigenous forests. A site index of 27 metres was adopted for these plantations based on criteria outlined earlier in Chapter 2. Up to 1974 planting season, over 7,400 hectares of plantation had been established with the bulk (about 5,600 ha.) located at Bondi Management Area.

The classification of the eucalypt forests was based on Baur's (1965) classifications of forest types for New South Wales. Four main species groupings approximating Baur's leagues were identified:-

(1) Spotted Gum (*E. maculata* Hook) forests
(2) Stringybark (*E. globoidea* Blakely, *E. agglomerata* Maiden, and *E. muellerana* Howitt) forests
(3) Messmate (*E. obliqua* L'Herit) - Brown Barrel (*E. fastigata* Dean ex maiden) forests
(4) Silver Top Ash (*E. sieberi* L. Johnson) forests.

Their location was based on data from two comprehensive surveys, the old forest resource surveys of the Forestry Commission of New South Wales (Byles, 1958) and the State-wide FORWOOD survey in 1971 which involved double-phase sampling (Watt 1971) and computer mapping techniques

2

(Hoschke and Wilson, 1974). Both surveys were supplemented by data from Hayden's (1971) vegetation survey. Details of these two surveys are given later in Appendix 10.3 (page A 100)

The FORWOOD survey showed that almost 90 percent of the indigenous forest belonged to these four species categories with slightly more than one third silvertop ash forests, 20 percent stringybark forests, almost 25 percent messmate-brown barrel forests and just under 10 percent spotted gum forests.

The stringybark and messmate-brown barrel forests were amalgamated into a single group termed mixed species eucalypt forests, which also included other less-extensively distributed commercial types such as blackbutt (*E. pilularis* Sm.) types, Sydney blue gum (*E. saligna* Sm.) - bangalay (*E. botryoides* Sm.) types, coastal grey box (*E. bosistoana* F. muell.) and woollybutt (*E. longifolia* Link.) types.

These three broad groupings (spotted gum, mixed species eucalypt and silvertop ash forests) were subdivided into the following eleven productivity groupings on the basis of site quality, structure (wet or dry sclerophyll, tall woodland and so on) and mature stand height serving as the main determinants of site quality.

(1) Spotted Gum Forests. Only two, high and average site quality forests were recognized.

(2) Silvertop Ash Forests. Five site quality classes were identified - site index 12, 15, 18, 21 and 24. Site index was defined as the average height of the tallest 25 trees per hectare (dominant height) in metres at age 20. It was assumed to be half the dominant height of the mature stand on the basis of height - age relationships for this species (Incoll, pers. comm.).

(3) Mixed Species Eucalypt Forests. Four site quality classes were adopted - high, average, low and depauperate. The main criterion applied was structure.

Management Units were classified either as spotted gum or as mixed species eucalypt forest in setting up the model, the latter group embracing both silvertop ash and mixed species eucalypts. Outside the Pulpwood Supply Zone, the intermixture of silvertop ash and mixed species eucalypts was difficult to separate and it was therefore convenient to treat them as one for management purposes. Within the Pulpwood Supply Zone, silvertop ash yields were estimated separately because of their dominance there and were then combined with yields for mixed species eucalypts.

The final criterion for identifying Management Units, slope, was subdivided into the following classes:-

(i) Pulpwood Supply Zone. Less than 10^0, 10^0 to 20^0, and greater than 20^0.

(ii) Mining Timber and Transition Supply Zones. Less than 20^0, 20^0 to 30^0 and greater than 30^0.

(iii) Sawlog Supply Zone. Less than 30^0 and greater than 30^0.

The degree of subdivision of a Management Area into slope classes depended on the range of management systems that might be applied and the products to be harvested from the forests. These are the same factors which determine the extent of the Supply Zones.

Management Units were classified into one of the following silvicultural classes since the silvicultural condition of the forest plays an important role in yield determination:-

(1) Silvicultural Class A. Virgin (or unlogged) forests.

(2) Silvicultural Class B. Forests which have been managed extensively for many years and which have been regularly or recently logged.

(3) Silvicultural Class C. Intensively-managed forests which have been protected and logged intensively for many years and which have been silviculturally treated at some stage.

Only economically and physically accessible forests were considered. Areas where slopes exceeded 30^0 or which were too rocky were therefore excluded. For areas where slope and rock were acceptable, the only restrictions were inadequate roading or where the yield of timber products was too low to be economic for logging. In the Mining Timber and Sawlog Supply Zones, this meant areas carrying less than 11 m^3 gross volume of sawlogs/ha. In the Pulpwood Supply Zone no yield limitation was applied.

The forest areas of the Lower South Coast were estimated firstly by transferring the boundaries of the cleared land from recent National Mapping Series aerial photos onto the Bateman's Bay and Bega Project Maps published by the Forestry Commission of New South Wales (scale 1:127,000) which include a broad subdivision into land tenures. Secondly uncleared land areas were estimated for each tenure and checked against data provided by the relevant public authority responsible for State Forests, Timber Reserves, State Parks, Nature Reserves and other forms of publicly-reserved land. Adjustments were made for non-forested vegetation types (for example, heath), major rock outcropping, rivers, creeks and other waterways, roads and so on.

A summary of the ownership position for the Lower South Coast Region is compared with that of New South Wales and Australia in Table 10.1.

The most prominent features of Table 10.1 are the unusually low proportion of forest in private ownership and the high proportion of publicly-owned land in the Region as compared to the whole of New South Wales. The private forests frequently consist of regrowth stands resulting from past unsuccessful attempts at land clearing. They have been exploited for their timber with little regard for forest management. Ownership of the private forest resource is also fragmented, consisting mainly of small farm landholdings. For example, out of 46 farms surveyed in the Shires of Eurobodalla, Imlay and Mumbulla during the Dairy Industry Survey from 1967/68 to 1969/70 twenty carried no forest at all, fifteen had less than 20 ha, five had 20 to 40 ha, four had 40 to 80 ha and only two carried more than 80 ha (Bureau of Agricultural Economics, unpub. data).

Nevertheless the privately-owned forests continue to represent a significant, but declining, source of supply for timber and must be considered in any Regional plan of forest production.

The major part of the category "other public" forest land consists of vacant Crown land, most of which is destined for National or State Parks. The bulk of it is located in the catchments of the Deua and Tuross Rivers.

TABLE 10.1

Forest areas (in hectares) by ownership categories for New South Wales, the whole of Australia and the lower South Coast Region

State, Territory, or Region	Area by Ownership (hectares)					Percentage Private of Total
	State	Other Public	National Park	Private	Total	
New South Wales	2,897,000	6,487,100	864,400	5,288,400	15,536,900	34.0
Australia	11,725,000	19,912,500	1,829,600	9,035,600	42,502,700	21.3
Lower South Coast	417,700	284,300	38,000	161,000	901,000	17.8

Notes: (1) Data for New South Wales and Australia were taken from the Report of Panel 2 on Forest Resources (FORWOOD, 1974a) and relate to 30/6/71. The Lower South Coast data relate to 30/6/73.

(2) Forest is defined as plantations and indigenous forest with an existing or potential mature stand height of twenty metres or more and cypress pine forest currently of commercial use regardless of stand height.

(3) Definition of ownership categories: "State" includes publicly-owned land, permanently reserved or dedicated primarily to timber production. "Other Public" includes publicly-owned land, vacant or occupied under lease, not specifically secured for permanent timber production, but on which control of timber rests with the Crown. "National Park" includes publicly-owned land, permanently reserved for purposes other than timber production. "Private" includes privately-owned land, and leasehold where the Crown has no control over timber rights.

Types of Forest Inventories

The inventory of the forests involved assessment of the following parameters for each management unit:-

(a) accessible forest area in hectares;

(b) average merchantable volume per hectare by product class;

(c) silvicultural condition.

The inventories undertaken during the past 20 years can be classified as either forest resource inventories or management surveys. Details of the type of inventory within six of these classes are given in Appendix 10.2 and they are summarized in Table 10.2. The forests of the Region have been covered by at least the FORWOOD forest resource inventory and well over half the Region by some kind of management survey.

The problem of welding these diverse classes of surveys into a consistent framework was simplified by the subdivision of the Region into Supply Zones since the survey procedures and the parameters assessed by the various surveys within each Zone were reasonably uniform.

Intensive management surveys have been carried out by the Forestry Commission in Bodalla, North and South Kioloa Management Areas and provided the basis for formal management plans proposed by the Commission. Most other State Forests have been covered by at least one kind of management survey, principally of the two-phase, sampling type. However in recent years, volume stratification has been increasingly used, usually for short term planning of logging operations and in relation to relatively small areas.

TABLE 10.2

Categories of surveys used in the assessment of the forest resource in the Lower South Coast Region

Forest Resource Inventories.

1. The forest resource classification system described by Byles (1958).

2. The FORWOOD survey of 1971 which consisted of the assessment of the total forest resource in New South Wales using aerial photographs for points located at each intersection of a variable width grid for the classification of broad stand parameters (Hoschke and Wilson, 1974).

Forest Management Inventories

1. Continuous forest inventories using permanently located plots in the field. Two areas have been assessed in this way - Bodalla and Kioloa Management Groups.

2. Assessment of existing growing stock by means of temporarily located field plots.

3. Assessment of existing growing stock by means of two phase sampling techniques (Watt, 1971) in which the first phase consists of an assessment of certain stand parameters using air photo plots and the second phase, the assessment of a sub-sample of phase 1 plots in the field for purposes of verification.

4. Stratification of an area into volume classes using low scale aerial photographs supplemented by field inspections.

Private forests south of Cobargo were assessed by means of either temporary plots or volume stratification using air photos. All private forests in the Region were included in the FORWOOD resource inventory of 1971.

Assessment of Forest Areas and Volume Availability

The procedures used to estimate the area of accessible forest and available merchantable volume per hectare are described in Appendix 10.3 (page A108). Briefly three steps were involved. The first was to identify the products to be assessed in each Management Unit and the system(s) of management to be applied. This was simplified by subdivision of the Region into Supply Zones. For example, the primary objective of management for the Pulpwood Supply Zone is obviously to produce pulpwood, based on some form of clearfelling system. The second step involved selecting the inventory on which to base assessment of the forest resource. For Management Areas not covered by a management survey, it was decided to adopt the FORWOOD forest resource inventory as the basis. Thirdly, the assessment of merchantable volume per hectare and area for each Management Unit was carried out. This presented no serious problem for Management Areas covered by management surveys but where it was necessary to rely on FORWOOD data, volume per hectare data from the management surveys were correlated with photo plot per hectare data from the FORWOOD inventory covering the same areas. These correlations were then used to estimate volume per hectare for Management Units not covered by management surveys by interpolating from the average photo plot volume per hectare derived from the FORWOOD inventory.

Estimates of the area of accessible forest and volume availability per hectare for each Management Unit are presented for each Supply Zone in Appendix 10.4 (page A113).

12

CHAPTER 11

STRATEGIES, YIELDS AND COSTS

The present value of net social benefits per hectare for each strategy was again estimated by residual imputation, using the procedure outlined in Chapter 3. With respect to eucalypt forests, this meant, firstly, definition of feasible strategies for each Management Unit; secondly, estimation of growth and yield based on inventory data from Chapter 10; and, finally, estimation of the costs incurred in implementing the strategies. The same costs, yields and strategies specified in the earlier comparative study were adopted for radiata pine plantations.

MANAGEMENT STRATEGIES

The main principles used in specifying strategies were discussed in Chapter 9. Briefly, strategies are dictated largely by the aims of management in each of the four Supply Zones and by the silvicultural characteristics of the Management Unit.

The main problem was to define a set of strategies capable of reconciling wood production in these forests with the changing demands over time, and with the possible change in land use of marginal farmland. In order to achieve this, the set must be varied in the pattern of yields over time while at the same time being technically feasible.

The planning horizon of 50 years during which constraints on management activities were assumed to operate was divided into ten 5-year planning periods. Operations performed within a Management Unit were assumed to be on one fifth of the area per year during each 5-year planning period.

Management Strategies - Softwood Plantations

Management Strategies adopted for pine plantations were the same as Forestry A, B and C described previously in the comparative analysis. To recapitulate they were as follows:-

A. Pulpwood production only. Rotations 15 and 20 years, coded A15 and A20 respectively.

B. Joint pulpwood and sawlog production. Rotations were 30, 35 and 40 years, coded B30, B35 and B40 respectively.

C. Sawlog production principally. Rotations again were 30, 35 and 40 years, coded C30, C35 and C40 respectively.

In the Bombala Plantation Working Circle, only areas of less than 20^0 slope were considered; for farmlands, all cleared land was included.

Management Strategies - Eucalypt Forests

The system proposed by Florence and Shepherd (1975) provided the basis for classifying management strategies in the eucalypt forests in the Region. Some adaptations were necessary to suit the special features of management in each Supply Zone.

1. Pulpwood Supply Zone

The primary aim of management in this zone was assumed to be sustained production of pulpwood at or above the committed levels during the planning horizon. Only clearfelling systems were considered economically feasible in this Supply Zone but several such systems were specified, each varying in the level of management intensity applied. Two broad systems were identified: (a) heavy cutting with minimum improvement treatment, and (b) clear-cutting and conversion to fully-stocked even-aged stands.

(a) Heavy cutting with minimum improvement Treatment

Two forms of even-aged management were identified within this broad strategy, one specified strategy "N" and the other, strategy "G". Both rely principally on natural regeneration from lignotubers, coppice and seedfall, either from heads of felled or retained trees. Where insufficient natural regeneration resulted such as at log dumps, on lower slopes and wet sclerophyll sites, some follow-up seedling planting or direct (aerial or manual) seeding is carried out. There is no thinning of the regenerated crop.

Under strategy "N", logging is carried out in coupes of at least 40 ha in area. Rotations of 30, 40, 50, 60, 70 and 80 years were evaluated and were coded N30, N40, N50, N60, N70 and N80 respectively. This strategy was restricted to areas with less than 20^0 slope.

Under strategy "G", coupe size can be much smaller, typically of the order of 20 ha. Only one rotation length of 40 years was considered which was equivalent to the length of the felling cycle adopted for clearfelling the existing eucalypt forest in the

Pulpwood Supply Zone. The felling cycle was assumed to consist of two cutting cycles of 2- years, with one half of each coupe clearfelled in each cutting cycle. This strategy was confined to areas in excess of 20^0 but less than 30^0 slope where wider-scale clearfelling systems such as strategy "N" would be prohibited on environmental grounds.

<u>(b) Clear-cutting and conversion to fully-stocked even-aged forests</u>

In terms of wood production per hectare, the fully-stocked even-aged stand is regarded as the most efficient system (Jacobs, 1955, and Florence and Shepherd, 1975). Because existing forests are far removed from this condition, intensive operations are needed to convert them to the even-aged state. Two strategies were adopted, one termed strategy "E" which was applied to slopes less than 20^0, and the other, strategy "I", which was restricted to slopes less than 10^0.

Stragety "E" is applied in different ways, depending on the structure of the forest. On the wetter sclerophyll, more productive sites, all commercial timber is logged and the site cleared by means of wind-rowing and burning but at minimal cost. The area is completely planted with a suitable naturally-occurring species such as messmate or silvertop ash at 1,500 trees per hectare but no fertilizer is applied; nor is any cultivation or thinning carried out.

In dry sclerophyll types, the area is again logged and cleared but natural regeneration is relied upon as in strategy "N". Again no cultivation or fertilisation is carried out. However, a pre-commercial liberation thinning is applied between age 5 and 10 with stocking reduced to 1,500 trees per hectare. No further thinning is carried out.

Rotations of 30, 40, 50, 60, 70 and 80 years were again adopted and were coded E30, E40, E50, E60, E70, and E80.

The most intensive management system adopted in the Pulpwood Supply Zone was strategy "I". It involves logging of all commercial timber and complete clearing and cultivation of the site. The site is then planted with a fast-growing species which is also resistant to Phytophthora cinnamomi (the "cinnamon fungus") such as <u>E. obliqua</u> Labill or <u>E. stjohnii</u> R.T. Bak. This system was similar to that applied by A.P.M. Forests Pty. Ltd. in Victoria where the site is cultivated by means of an offset disc-plough and an individual tree application of 113 gm of superphosphate is applied, followed by a dressing of ammonium sulphate and ammonium nitrate (18% N and 8% P) at 227 gm/tree one year later. Only one rotation of 10 years was considered and it was coded I10.

2. Management Strategies - Mining Timber Supply Zone

The primary aim in this Zone is the production of mining timber and sawlogs subject to the constraints imposed by the Regional models. Both selection and even-aged systems of management were considered to be feasible.

(a) Extensive selection management of uneven-aged stands

This is referred to as management strategy "S". It consists essentially of selection logging, minimum protection and no other silvicultural treatment. The actual silvicultural practice to be applied depends largely on the condition of the forest and its structure. In old-growth forests in the western parts of the Region, this system would probably involve removal of most of the available sawlogs whereas in the less steep country nearer the coast selection logging would be more widely applied because of the long history of selection logging in these stands and to a much lesser extent, improvement treatment.

Selection systems used in these better managed forests near the coast can vary from individual tree selection to group selection (or clearfelling small groups of trees).

(b) Intensive selection management of uneven-aged stands

This is designated management strategy "Q". A range of silvicultural systems involving follow-up improvement treatments may be carried out. It is restricted to slopes less than 20^0. Because of the history of logging in many of the forests and the resultant low level of merchantable growing stock relative to the unmerchantable component, the most widely practiced system would be the quality stem retention system proposed by Furrer (1972) for spotted gum forests in the Region. It consists of the removal of all trees failing to meet reasonable bole and crown quality standards, and improvement treatment following logging operations.

In the dry sclerophyll forests, natural regeneration is relied upon but in the wet sclerophyll sites some enrichment planting is necessary. In areas where a pulpwood outlet is available, trees removed by treatment may be diverted to a portable chipper for conversion into woodchips.

(c) Clear-cutting and conversion to fully-stocked, even-aged stands

This system of management was applied as follows:-

(i) Wet sclerophyll forests. These forests are typically over-mature and contain only limited merchantable advanced growth. Regeneration by natural means is extremely difficult and thus complete clearing of the site after logging followed by planting with a suitable species is necessary. Blackbutt was selected for mixed species eucalypt forests of high site quality in North and South Kioloa Management Areas, messmate for mixed species eucalypt forests of high site quality in other Management Areas and spotted gum for high site quality spotted gum types. No fertilisation or cultivation of the site is applied. Only areas less than 20^0 slope and at least 20 ha in size were considered.

(ii) Dry sclerophyll forests. Again complete logging and clearing of the site is envisaged. Some baring of mineral soil by the tractor during clearing is also carried out in order to provide a suitable seed-bed for seedling regeneration. Coppicing and regrowth from lignotubers supplement the seedling regeneration.

Seed trees are removed at about 5 years and the regenerated stand is pre-commercially thinned and spaced out to the desired stocking at about 5 to 10 years of age.

Two strategies were specified:-

Management Strategy "T". It was assumed that only mining timber would be produced under this strategy. Thinning is carried out from above when the stand is capable of supplying an economic yield of 20 cm d.b.h. trees. A rotation of 20 years was adopted for blackbutt (coded T20) and 40 years was adopted for other species (T40). It was decided to restrict the application of this strategy to mixed species eucalypt forests of high site quality and high site quality spotted gum forests in North and South Kioloa Management Areas and to average site quality spotted gum forests. This was considered necessary to avoid sacrificing advanced growth capable of producing sawlogs and to prevent the two linear programming models from becoming too large. This approach also seemed to fit in with the policy of the Forestry Commission in the Region.

Management Strategy "J". Both mining timber and sawlogs were assumed to be produced under this strategy. Rotation length is varied according to Management Unit and the strategy is coded Jxx where xx denotes the rotation length. Again thinning is essentially from above but greater weight is given to favouring the trees selected for the final sawlog crop. It was decided not to apply this strategy in the two models during the 50-year planning horizon partly because it is unlikely to be seriously considered as part of normal management practice in the Region but partly also to avoid sacrificing advanced growth of sawlog quality. However, it was used to estimate terminal values for all strategies in the Mining Timber Supply Zone included in the two Regional models.

All strategies were considered to be feasible in the Transition Supply Zone while in the Sawlog Supply Zone only Management Strategy "S" was adopted mainly because of the steepness of much of the terrain in this Zone and the environmental dangers this implies under more intensive management systems.

The strategy specified in the planning model may not necessarily be continued on indefinitely once past the end of the 50-year planning horizon. In the Mining Timber Supply Zone, it was assumed that the designated strategy would switch instantaneously to strategy "J" following completion of the rotation or cutting cycle overlapping the end of the planning horizon. The primary reason for this was the greater reliability of the growth and yield data for the even-aged strategies.

In the Sawlog Supply Zone, it was assumed that timber production would cease altogether at the end of the cutting cycle straddling the planning horizon. However in the Pulpwood and Transition Supply Zones, the strategy yielding the maximum present value per hectare was selected.

GROWTH AND YIELD

The same yield tables used for Forestry A, B and C in the comparative study in Part A were adopted for Radiata A, B and C respectively in the planning models, and no further elaboration of these is required here. The following discussion is therefore confined to eucalypt forests.

It was apparent at the beginning of the investigation that growth and yield data on eucalypt forests in the Region were extremely limited. The only well-documented information was reported by Furrer (1971) but this was confined to spotted gum. A comprehensive study of growth through the establishment and remeasurement of suitably-located plots was also out of the question, because of the complexity and size of the resource as well as the more pressing factor, time. There was also the problem that only a relatively small part of the forests had been inventoried in detail, and frequently the only parameter describing stands was merchantable volume per hectare. Thus growth models for uneven-aged forests had to be based solely on this parameter and not on the more usual parameters such as stand basal area or stand diameter distribution, and stand height.

Because the present value criterion seemed to be less sensitive to changes in growth than to the existing volume per hectare in the stand, it was considered that a much less extensive sampling of the Region's forests supplemented by data from similar forests in New South Wales and Victoria would provide a satisfactory basis for estimating growth. Thus fifty representative plots established by the Forestry Commission of New South Wales in 1960 and 1961 as part of the continuous forest inventory of the Bodalla Management Group were remeasured by the author in 1972 and used for developing growth equations for uneven-aged forests. For even-aged management strategies, Regional data (Furrer, 1971 and Forestry Commission of New South Wales, unpub. data) were supplemented with yield models for comparable forests outside the Region, particularly from Victoria.

Florence and Shepherd (1975) provide some guide to possible yields under the different management systems proposed in this study. Under extensive systems, they estimated that yields might vary from 1.5 to 6 m^3/ha/an where heavy cutting and minimum treatment is applied and from 0.5 to 3.0 m^3/ha/an for selection logging. Under intensive management systems, yields ranging from 10 to 25 m^3/ha/an might be expected in stands managed under clearcutting systems, and if selection logging is applied, from 2 to 6 m^3/ha/an. These estimates are generally consistent with those reported by Jacobs (1955), Hoschke (1966), and Curtin (1970a),which are based on more specific studies of growth, principally in the North Coast forests of New South Wales.

Curtin (pers. comm.) provided some useful guidelines on growth and development in typical eucalypt forests:-

(1) Differences in diameter growth between wet and dry sclerophyll eucalypts are usually not great and therefore the main parameter affecting volume production is bole height.

(2) The productivity of forests dominated by types belonging to the messmate/brown barrel league is comparable to blackbutt while that of even-aged

stringybark forests lies somewhere between spotted gum and blackbutt. However, current annual diameter increment tends to decrease with age in the latter case.

(3) In general, mean annual volume increment maximizes at about 40 to 50 years of age in most species while mean basal area increment reaches a peak much earlier.

(4) The productivity of messmate is approximately comparable with that of high site quality silvertop ash forests and yields for <u>E. fastigata</u> would probably be similar to those for messmate.

The approach adopted throughout this part of the investigation was to cover as wide a range of strategies as possible for those forests where a growth and yield simulator was available and to limit yield estimation on other forests to those strategies for which reliable data could be obtained.

<u>Estimation of Yields</u>

Further details of the bases on which yields were estimated are provided in Appendix 11.1 (page A 113). In this section, however, the more important features of the yield calculations are discussed.

I Even-aged Management Strategies in the Pulpwood Supply Zone

1. Silvertop ash forests

A tree and growth simulation model based on the STANDSIM model for E. regnans (Opie, 1962) was used to estimate yields for even-aged forests of Silvertop ash (Incoll, 1974). For stands less than 15 years old, the main variables requiring specification in the model are initial stand density (number of trees per hectare) and site index, defined as the average height in feet of the 25 largest diameter trees per acre (or 62 trees per hectare). For stands older than 15 years, age of stand, diameter distribution per acre and site index must be specified.

It was assumed that the general habit and growth characteristics of silvertop ash in the Lower South Coast are much the same as in Victoria where data for Incoll's model were collected. However the model was found to over-estimate basal area by 50 percent, thought to be principally due to the effects of fire and the inverse relationship between site index and gross basal area growth in the relative density model developed by Incoll.

The following basal area function was estimated from data from 106 plots supplied by Incoll, using multiple regression analysis (Grosenbough, 1967):-

Ln (B) = 0.00447*S - 7.4580/A - 28.2098/A*A + 2.5885*RD
-0.7206*RD*RD + 3.619

where B denotes the standing basal area per acre in square feet;

S denotes site index in feet;

A denotes age in years;

and RD denotes relative density which is the ratio of actual standing basal area per acre to that for a fully-stocked stand of similar age.

The multiple coefficient of determination (R^2) was 0.9368, and the regression coefficients were jointly significantly different from zero at the 0.001 percent level. This relationship seemed more sensible than the original one estimated by Incoll, since basal area for any given age increases with increasing site index.

The ordering of the subroutine INC in the main STANDSIM program was also changed since net, and not gross, basal area increment is estimated by the new basal area growth function. Basal area increment was distributed over the live trees at the end of the growth cycle rather than at the beginning as is done in Incoll's model. Trees are killed at the start of each cycle, rather than during the cycle.

In spite of these changes, the yields calculated by means of the model were still higher than those measured in plots in the Region. Some further adjustment was considered necessary to simulate under-stocked conditions anticipated in the various strategies, and to convert total volumes per hectare to merchantable volumes.

For strategy "N", pulpwood volume was reduced by 30 percent and sawlog volume by a further 20 percent. For strategy "E", no adjustments were made to pulpwood volumes but sawlog volumes were reduced by 15 percent to account for unmerchantable trees.

Pulpwood and sawlog volumes per hectare for strategies "N" and "E" are presented in Table 11.1 for the range of site indexes anticipated and for rotations 30, 40, 50, 60, 70 and 80 years.

TABLE 11.1

Pulpwood and sawlog yields in m^3 per hectare for unthinned even-aged stands of silvertop ash of varying site index managed under strategies "N" and "E"

Strategy	Rotation (Years)	Site Index 15		Site Index 18		Site Index 21		Site Index 24	
		Pulp	Sawlog	Pulp	Sawlog	Pulp	Sawlog	Pulp	Sawlog
"N"	30	34	-	68	-	92	-	160	-
	40	81	-	136	-	197	-	259	-
	50	125	2	165	4	245	10	259	24
	60	154	6	213	15	270	30	297	62
	70	197	19	236	34	267	61	261	127
	80	195	36	237	59	244	106	183	229
"E"	30	139	-	179	-	228	-	289	-
	40	187	-	231	-	303	-	379	-
	50	224	4	276	11	339	29	375	71
	60	259	12	307	28	345	66	360	129
	70	274	32	310	57	327	116	302	221
	80	272	57	295	97	295	173	214	338

In general, the shorter the rotation, the greater the relative difference in yield between high and low site index stands. Pulpwood plus sawlog production under strategy "E" is more than 50 percent greater than that under strategy "N" and sawlog production is particularly enhanced by strategy "E".

2. Mixed species eucalypt forests of high site quality

Yields were based on messmate (*E. obliqua*), the dominant species occurring in these forests and were estimated from yield tables calculated by Hall (1956) for this species. Similar adjustments to those applied to silvertop ash for under-stocking and defective trees were applied to these total volumes per hectare and the resulting yields are presented in Table 11.2.

TABLE 11.2

Pulpwood and sawlog yields for unthinned, even-aged stands of high site quality mixed species eucalypts forests managed under strategies "N" and "E" for various rotation lengths

Strategy	Age	Total Volume (m^3/ha)	Proportion of 20+ cm d.b.h.o.b. and to 10 cm s.e.d. (%)	Merchantable Volume (m^3/ha)	
				Pulpwood	Sawlog
"N"	30	372	42.0	156	-
	40	476	56.0	267	-
	50	567	59.0	337	-
	60	651	63.0	322	88
	70	720	66.5	295	184
	80	823	63.5	176	346
"E"	30	372	75.0	279	-
	40	476	80.0	381	-
	50	567	83.3	388	84
	60	651	82.8	373	166
	70	720	85.5	330	286
	80	823	85.5	214	490

3. Mixed species eucalypt forests of average site quality

Curtin (pers. comm.) considered that the potential productivity of these forests lies somewhere between dry sclerophyll spotted gum and high site quality messmate forests. Thus, in the absence of more suitable data, the average total volume per hectare for these two productivity groupings using data from Furrer (1971) and Hall (1956) was estimated. It was found that the resulting yields were almost identical with Hall's (1956) site index 27 messmate yields and therefore this was adopted as the basis for estimation purposes. The same adjustments were made for stocking and conversion to sawlog and pulpwood yields as for high site quality mixed species eucalypt forests. The yield tables derived on this basis are presented in Table 11.3.

TABLE 11.3

Estimated pulpwood and sawlog volumes in m^3 per hectare for strategies "N" and "E" in unthinned average site quality mixed species eucalypt forests

		Rotation in Years					
Strategy	Product	30	40	50	60	70	80
"N"	Pulpwood	66	134	188	223	251	254
	Sawlog	-	-	-	15	38	65
"E"	Pulpwood	175	228	293	316	318	310
	Sawlog	-	-	-	35	75	120

4. Mixed species eucalypt forests of low site quality

These forests were considered to be incapable of producing economic yields of sawlogs and therefore production was confined to pulpwood only. The yield tables presented in Table 11.4 were based on data reported by Alexander (1954) and Curtin (1970b).

TABLE 11.4

Pulpwood yields per hectare for unthinned even-aged stands of low site quality mixed species eucalypt forests at different ages

Age	Trees per ha	Basal Area (m^2/ha)	Average d.b.h. (cm)	Pulpwood Volume (m^3/ha)
30	1,060	15.5	13.6	20
40	788	19.2	17.6	43
50	598	21.6	21.4	73
60	445	24.0	25.6	136
70	331	25.5	30.3	157
80	246	25.5	35.9	165

These yields are probably on the low side since they do not reflect the relatively high proportion of fast growing species such as *E. sieberi* which typically occur in these forests.

5. Intensively-managed plantations of fast-growing eucalypts

This strategy was restricted to Management Units close to Edrom and less than 10^0 slope. Yields were based on data supplied by Cromer (pers. comm.) and these are set out in Table 11.5.

TABLE 11.5

Pulpwood yields in m^3 per hectare for intensively-managed eucalypt plantations and a rotation of 10 years

Mixed Species Eucalypts Productivity	Pulpwood Yield
1. High site quality	210
2. Average site quality	175
3. Low site quality	140

This is the highest yielding strategy adopted in the analysis but much higher levels of inputs are required to achieve these yields.

II Even-aged Management Strategies in the Mining Timber Supply Zone

1. Mixed species eucalypt forests of high site quality in other than North and South Kioloa Management Areas

Yields were based on a provisional yield table for thinned messmate of about site index 27 (Mann, 1955). However, to reflect the higher site quality of these forests, yields were increased to the level anticipated in site index 33 forests by using the ratio between total volume per hectare for unthinned site index 27 and 33 messmate stands reported by Hall (1956). The yield tables derived for strategy "J" are presented in Table 11.6.

TABLE 11.6

Mining Timber and sawlog yields in m^3 per hectare for thinned stands of mixed species forests of high site quality in areas other than North and South Kioloa Management Areas of the Mining Timber Supply Zone

Age	Volume Thinned		Volume Clearfelled
	Mining Timber	Sawlogs	Sawlogs
20	14	-	-
30	55	-	-
40	-	62	244
50	-	82	272
60	-	-	264

Messmate was considered to be the most representative species on these sites and since a low stand density was adopted, the yields should be capable of being achieved.

2. Mixed species eucalypt forests of high site quality in North and South Kioloa Management Areas

Blackbutt (E. pilularis) is the species proposed for such sites, particularly in view of the fact that it occurs naturally in these Management Areas. Thus the provisional yield table developed for thinned even-aged stands of blackbutt (Curtin, 1969) was adopted and is presented in Table 11.7 for strategies "J" and "T".

TABLE 11.7

Mining Timber and sawlog yields in m^3 per hectare for thinned high site quality mixed species eucalypt forests in North and South Kioloa Management Area

Age	Mining Timber	Sawlog
Mining Timber Production only ("T")		
12	30	
20	174	
Joint Mining Timber and Sawlog Production ("J")		
12	30	
20	52	
30	41	41
40		76
70		374

3. Mixed species eucalypt forests of average site quality

A hypothetical yield table was constructed from data from several sources but particularly those reported by Furrer (1971) for even-aged spotted gum and Mann's (1955) provisional yield table for site index 27 messmate stands. The yield tables estimated are presented in Table 11.8 for strategies "T" and "J".

TABLE 11.8

Mining timber and sawlog yields in m^3 per hectare for thinned, even-aged stands of average site quality mixed species eucalypt forests managed under strategies "T" and "J"

Age	Thinned		Clearfelled	
	Mining Timber	Sawlogs	Mining Timber	Sawlogs
1. Strategy "T" - Mining Timber Only				
20	43	-		
30			66	
40			146	
2. Strategy "J" - Joint Mining Timber and Sawlog Production				
30	26			
40	51			
60		74		190
70				172
80				208

The rotation adopted for strategy "J" was 80 years and for strategy "T", 30 years. This productivity grouping is the most commonly occurring in this Supply Zone and therefore the best available information was sought in constructing the yield table.

4. Spotted gum forests of high site quality

Furrer's (1971) yield tables for even-aged spotted gum were adopted and are presented in Table 11.9.

TABLE 11.9

Mining timber and sawlog yields in m^3 per hectare for thinned even-aged high site quality spotted gum forests managed under strategies "T" and "J"

Age	Thinning or Clearfelling	Mining Timber	Sawlog
Strategy "T" Mining Timber Production Only			
25	Thinning	33	-
40	Clearfelling	185	
	Total	218	
Strategy "J" Joint Production of Mining Timber and Sawlogs			
25	Thinning	30	-
40	Thinning	56	-
60	Thinning	5	37
80	Clearfelling	-	200
	Total	91	237

These estimates were based on data from average as well as high quality stands and therefore the true productivity of these forests is probably under-estimated.

5. Spotted gum forests of average site quality

The yield tables presented in Table 11.10 were based principally on data from thinned even-aged spotted gum stands of low to average site quality at Corunna State Forest (Furrer, 1971 and unpub. data, Forestry Commission of New South Wales).

TABLE 11.10

Estimated mining timber and sawlog yields in m^3 per hectare for average site quality spotted gum forests managed under strategies "T" and "J"

Year	Thinning or Clearfelling	Mining Timber	Sawlogs
Strategy "T" Mining Timber Production Only			
25	Thinning	15	
40	Clearfelling	91	
Strategy "J" Joint Mining Timber/Sawlog Production			
25	Thinning	15	-
40	Thinning	37	-
60	Thinning	22	22
80	Clearfelling	-	97
	Total	74	119

Again only one rotation was applied to each strategy.

No consideration was given to the management of low site quality mixed species eucalypt forests because of their low productivity and the fact that all of the production from this Supply Zone could be achieved by restricting management to better site quality mixed species eucalypt and the spotted gum forests. Even-aged management of these forests was also considered to represent a doubtful economic proposition.

III Yields for Selection Management Strategies

Yields for selection management strategies were simulated by means of a computer programme, SELFOR, written specifically for this purpose. It requires specification of the following:-

(a) The volume of merchantable timber 10+ cm d.b.h. in planning period 0, designated V_0. Sawlogs and, where relevant, mining timber, were included.

(b) The management strategy i.e. the management system (S or Q) and the planning period in which logging commences.

(c) The productivity grouping (or management unit) of the forest. Four productivity groupings were defined, each of which is shown in the Table 11.11 along with its corresponding management unit code.

TABLE 11.11

Management Unit codes for each major productivity grouping

	Productivity Grouping	Management Unit Codes
(i)	High site quality spotted gum	S1, SA and SH
(ii)	Average site quality spotted gum	S2, SB and SL
(iii)	High site quality mixed species eucalypts	M2, MB, MC and MH
(iv)	Average site quality mixed species eucalypts	M3, ME, MF and ML

(d) The silvicultural condition of the forest (i.e. the silviculture class) in terms of one of the following broad categories referred to earlier in Chapter 10:-

A - Virgin (unlogged),

B - Extensively managed forests,

C - Intensively managed forests.

The programme consists of the following:-

(i) Identifying the management strategy, the management unit and the silvicultural class, and registering the value of V_O.

(ii) Simulating the growth of V_O, where applicable, up to the planning period "n" in which first logging is specified as occurring in the management strategy.

(iii) Calculating the volume of sawlogs and, where applicable, mining timber cut in planning period "n".

(iv) Calculating subsequent yields of sawlogs and mining timber based on:-

  (a) The volume retained (R) after logging in planning period "n";

  (b) Growth associated with R up to the time of logging;

  (c) Any volume ingrowth.

The application of the above steps depends not only on the specification of the management strategy, management unit and silvicultural class but also on the functions defining growth and the volume of timber removed at logging. These functions are incorporated in the simulation model. Growth equations were based on growth data for forests in the Region wherever possible, but it was necessary to run a number of simulations to select the most appropriate assumptions with respect to cutting cycle length and timber removals. The criterion for selecting the most appropriate assumptions was that they should permit a sustained level of production i.e. that a steady state could be achieved in the long term. Details of the growth functions and other aspects of the model are given in Appendix 11.2.

The number of cutting cycles and their lengths are presented in Table 11.12 for each strategy and productivity grouping.

TABLE 11.12

Number and length of cutting cycles adopted for each selection management strategy and productivity grouping

Strategy	Productivity Grouping	Number of Cutting Cycles	Length of Cutting Cycles (years)
S	High site quality spotted gum	2	40
	Average site quality spotted gum	2	40
	High site quality mixed eucalypts	2	30
	Average site quality mixed eucalypts	2	40
Q	High site quality spotted gum	2	30
	Average site quality spotted gum	2	40
	High site quality mixed eucalypts	3	20
	Average site quality mixed eucalypts	2	40

The shorter cutting cycle was associated with the high site quality forests. For intensively-managed high site quality mixed species eucalypt forests it extended over only 20 years.

The yields for these strategies vary according to the standing volume and it is not possible to summarize them simply. Further details on the basis of the yields are given in Appendix 11.2.

PRODUCTION COSTS

Costs for each management strategy are present in Appendix 11.3. With the exception of Strategy "I", costs for field operations ("field costs") were based on data supplied by the Forestry Commissions of New South Wales, Victoria and Tasmania. Strategy "I" field costs were estimated from basic input data provided by A.P.M. Forests Pty. Ltd. for comparable operations in Victoria. Where necessary, however, appropriate adjustments to these costs were made for differences in topography, silvicultural conditions and roading intensity.

Costs were classified and treated in the same way as that described earlier for radiata pine plantations in the comparative analysis. Past costs were regarded as sunk costs and administrative costs were again assumed to be equal to 50 percent of field costs. The same loading of 10 percent for overheads, such as wet weather, was adopted.

Similar sources of financing different categories of costs were also assumed. Field costs in the first rotation or cutting cycle were financed by means of loan funds for all operations other than annual maintenance and protection and survey costs. Reinvestment of earnings was used to finance other field costs during the first rotation and all field costs during subsequent rotations or cutting cycles. Administrative costs were financed from the Consolidated Revenue Fund. The same values were adopted for the social opportunity costs of the three sources of funds - loan funds, reinvestible earnings or trust funds and consolidated revenue funds. The social opportunity of existing forest land was assumed to be zero, the reason being that the main alternative uses to wood production in these areas consisted of some form of recreation or conservation, uses for which it was impossible to place a value.

Where conversion of marginal farmland to radiata pine plantations was entertained, however, a value reflecting benefits foregone from farming in its efficient form was incorporated. This was considered to be equal to the present value of the net social benefits derived from the most profitable farming alternative in the comparative analysis, Beef Grazing A.

Costs for the radiata pine plantation alternatives were assumed to be identical to those used in the comparative analysis with the exception of clearing and roading costs in the Bombala Plantation Working Circle where more appropriate data to the actual setting were adopted.

CHAPTER 12

SHADOW PRICES FOR WOOD PRODUCTS

Shadow prices for pulpwood and sawlogs from radiata pine plantations were based on the principles described earlier in Chapters 5 and 6. In the case of the Management Areas involving farmland in model R2, the same shadow prices calculated in these two Chapters were simply adopted. However, further shadow prices had to be derived for Management Areas in the Bombala Plantation Working Circle in model R1.

The prices for products harvested from eucalypt forests were based on a new set of assumptions and data, although the principles involved were much the same as those adopted for radiata pine plantations. Production from these forests was assumed to be confined to three commodities - pulpwood, mining timber and sawlogs. Although this is an incomplete list, the quantity of other commodities produced from these forests such as poles, girders and posts, is relatively unimportant by comparison. The derivation of these shadow prices was somewhat more complex than in the case of those for radiata pine plantations because of variation in the age, species, composition and silvicultural characteristics of the eucalypt forests.

The main purpose in this Chapter is to outline the basis on which the shadow prices for products from eucalypt forests were calculated. Complete listings of shadow prices for all products from both radiata pine plantations in the Bombala Plantation Working Circle and eucalypt forests are also presented.

PRICES FOR PULPWOOD FROM EUCALYPT FORESTS

The market for pulpwood from the Region's eucalypt forests is far removed from the model of perfect competition. The bilateral monopoly between the Forestry Commission and the woodchip company, referred to previously in Chapter 6, represents the dominant feature of the market for pulpwood from Crown lands and a classical monopoly situation exists for pulpwood from private property i.e., a market in which there is one buyer and many competing sellers, many of whom have only a limited knowledge of the market in which they operate.

Price data in a recent financial analysis of the wood chip project (Davies et al., 1974) provide some indication of the extent to which these market imperfections have distorted stumpage prices. Based on the terms of the negotiated agreement between the Commission and Harris-Daishowa (Aust.) Pty. Ltd., prices for pulpwood ranged from \$1.64 to \$2.17 per tonne.

Distance from the chipmill and topographical factors (rock, slope, etc.) were the main factors taken into consideration in assessing these values.

However, assuming an average haulage cost of 4 cents per tonne (see Appendix 5.3), the range in stumpage prices, should be of the order of \$3.60 per tonne, not \$0.53 per tonne, as indicated above for the negotiated prices. This is based on a difference of 90 kilometres between the nearest and furtherest sub-project areas. It seems that the Commission has either negotiated a bargain price or the areas closest to the mill are subsidizing the more distantly located areas. From a social pricing viewpoint, insofar as wood production is concerned, correct decisions on spatial allocation are unlikely. The residual value pricing method therefore was considered to offer a more appropriate method for assessing stumpage prices.

Because it is anticipated that Australia will be self-sufficient in short fibre (eucalypt) pulp in the long term (FORWOOD, 1974a), pulp produced from the pulpmill (assumed to start up in 1995/96) will most likely be exported rather than sold in the domestic market. However there seemed to be little point in basing residual values on the f.o.b. export price for this pulp in preference to that for woodchips since preliminary studies indicated insignificant differences in the derived prices. Therefore, stumpage values were based on the f.o.b. price for woodchip exports throughout the planning horizon.

The Pricing Equation

Recent studies of the pulping properties of species similar to those being harvested from the Region (Cromer and Hansen, 1972; Hall et al., 1973; Watson et al., 1974) have indicated the need for the pricing equation for eucalypt pulpwood to take into account inherent differences in wood properties, differences in age and intensity of management. This was achieved by incorporating basic density and pulp yield, the two factors considered to be the most important influencing price and likely to be affected by age and management.

The pricing equation adopted was as follows:

$$P_{ij} = (X - M)\ KB_i^{\,2}\ Y_i/B_oY_o - F_iB_i - L_{ij} \qquad (12.1)$$

where P_{ij} denotes the stumpage price for pulpwood category i at Management Area j in \$ per m^3 of pulpwood;

X	denotes the f.o.b. value of woodchips of category $i = 0$ at Edrom in \$ per green tonne;
M	denotes the cost of yarding, chipping, stock piling, loading, wharfage, and harbour dues in \$ per green tonne of woodchips;
K	denotes the factor for converting green tonnes of chips for pulpwood category $i = 0$ to bone dry tonnes (BDMT);
B_i	denotes the basic density of pulpwood category i in tonne oven-dry weight per m^3;
Y_i	denotes the yield of bleached kraft pulp from pulpwood category i expressed as a proportion of the oven-dry weight of pulpwood used;
F_i	denotes the difference in cost of freight from Edrom to Japan between pulpwood category i and pulpwood category 0 in \$ per BDMT;
L_{ij}	denotes the cost of logging and hauling pulpwood category i from Management Area j to the chipmill in \$ per m^3; and
Y_o, B_o	denote the pulp yield and basic density respectively for pulpwood category $i = 0$.

The first part of the equation, $(X - M)\ KB_i^2\ Y_i/B_oY_o$, approximates the value per m^3 for pulpwood category i on truck in mill yard at Edrom. The second part, $F_i\ B_i$, adjusts the value of the first term, for any differential in freight costs between pulpwood categories. Both parts express the value for pulpwood category 0 in terms of the equivalent value of usable fibre recovered from a cubic metre of pulpwood category i. This assumes that the number of BDMT's of each pulpwood category i carried to Japan each trip will be identical. Possible cost differentials associated with the manufacture of pulp from different categories of pulpwood had to be disregarded because of insufficient data even though some differentials are known to exist (Watson et al., 1974).

Three pulpwood categories were identified:

(1) Pulpwood from old growth forests ("old-growth" pulpwood);

(2) Pulpwood from regrowth forests resulting from the natural regeneration of old growth forests and from extensively managed plantations ("regrowth pulpwood"); and

(3) Pulpwood from short-rotations of fast-growing eucalypt plantations resulting from intensively managed plantations ("fast-grown" pulpwood).

Old-growth pulpwood was adopted as the base pulpwood category i = 0.

Free-on-board Price of Woodchips (X)

The f.o.b. price of woodchips at Edrom (X) was estimated to be equal to the weighted average f.o.b. value of \$14.64/green tonne for woodchips exported from Australia in 1972 and 1973 (House of Representatives, Australia, 1974), plus a margin of \$0.40 per green tonne for lower shipping freight costs from Edrom because of the shorter ocean haul to Japan compared with that from Australia as a whole and on data reported in trade journals.

Cost of Chipping and Port Handling (M)

Parameter M, which includes yarding, chipping, stockpiling, loading, wharfage and harbour dues was estimated to be \$4.50 per green tonne of chips for "old-growth" and "regrowth" pulpwood. This was based on data from a number of sources, some of which were confidential, and was considered to be reasonable for an efficient woodchipping operation based on eucalypts.

A cost of \$2.95 per cubic metre was adopted for fast-grown pulpwood and is identical to that used in Chapter 5 for radiata pine plantations.

Basic Density (B_i) and Pulp Yield (Y_i)

The basic density and yield of bleached kraft pulp adopted for each pulpwood category are presented in Table 12.1. Except for fast-grown pulpwood, estimates were made on a bark-off basis.

TABLE 12.1

Estimated basic densities and bleach kraft pulp yields of different categories of eucalypt pulpwood

Pulpwood Category	Basic Density (t/m^3 O.D.)	Bleached Kraft Pulp Yield
Old-growth	.66	.40
Regrowth	.60	.45
Fast-grown (includes bark)	.55	.43

The values of these two parameters for old-growth pulpwood were weighted average values for old and medium-aged wood reported by Hall et al., (1973) using as weights the relative proportions by volume of the main species represented in pulpwood operations in the Pulpwood Zone (Forestry Commission of New South Wales, unpub. data). These were then checked against data reported by Watson et al., (1974) for wood of similar age-classes. A similar procedure was used for regrowth pulpwood.

The data for fast-grown pulpwood was based on a study by Cromer and Hansen (1972) in which values of wood properties for two-year old, fertilized plantations of E. globulus were given. The reported value for basic density was increased slightly to account for the greater age (10 to 15 years old) of the plantations from which fast-grown pulpwood was assumed to be harvested.

Because the yields were expressed in terms of bleached grades of pulp a further 3 percent was deducted for fibre losses from screening and bleaching.

Conversion Factor (K)

A conversion factor of 1.72 green tonnes of chips of old-growth pulpwood per BDMT of chips was adopted. It was based on 1.1 m^3 gross volume (including defect) of pulpwood/tonne of green chips, a defect of 20 percent true volume, and the basic density of 0.66 tonne/m^3 for old-growth wood in Table 12.1.

Ocean Freight Differential (F_i)

In a preliminary analysis little difference was found between the unit cost of shipping old-growth and regrowth pulpwood chips. Thus although higher freight costs were associated with shipping fast-grown pulpwood chips, it was considered that the margin could be ignored since it would be more than offset by savings in pulp manufacture and after adjusting for differences in basic density.

Mill-Yard Prices

Substituting appropriate values for the above parameters in equation (12.1) the prices free-in-yard (f.i.y.) at the mill were calculated to be $11.97 and

\$11.12 per m^3 for old-growth and regrowth pulpwood respectively.

Equation (12.2) was modified slightly for calculating the free-in-yard (f.i.y.) mill price for fast-grown pulpwood as follows:

$$P_{ij} = X.K.\ B_i^{\ 2}\ Y_i/B_oY_o - M - L_{ij} \qquad (12.2)$$

where P_{ij}, X, K, B_i, Y_i, B_o, Y_o and L_{ij} are as defined previously;

and M denotes the cost of chipping, yarding, etc. per cubic metre of pulpwood (not chips as denoted in equation (12.1)).

The price for fast-grown pulpwood was estimated to be \$9.80 per m^3 solid volume by this equation.

Logging Costs (L_{ij})

Haulage costs were based on the same rate used to determine stumpage prices for radiata pine pulpwood, i.e., the base rate of 3.90 cents/tonne/km calculated in Appendix 5.3 for haulage distances less than and greater than 50 km respectively. Thus for a conversion factor of 1.13 tonnes/m^3 solid volume, the corresponding unit costs for old-growth pulpwood were 5.0 and 4.5 cents/m^3/km respectively.

The same rates were adopted for regrowth and fast-grown pulpwood on the assumption that the cost increasing effect of the higher moisture content of these two categories on quantity of fibre per load actually carried would be largely negated by their much lower defect. This would be particularly so in case of long-length haulage systems.

Harvesting costs (i.e., felling, debarking, delimbing, cross-cutting, snigging including tracking and roading, splitting, loading and overheads) for old-growth wood were estimated to be $6.35/m^3 solid volume plus adjustments for slope where considered to be appropriate. They were based on data from several sources including APM Forests Pty. Ltd. (unpub. data), De Vries (pers. comm.) FORWOOD (1974b) and from the Economics and Marketing Bulletin of the Forestry Commission of New South Wales as at 1 July 1973. Costs adopted for individual items were as follows:

(a) Felling, debarking, delimbing and cross-cutting - $1.60/m^3;

(b) Snigging, including tracking and roading - $1.90/m^3;

(c) Loading - $0.50/m^3;

(d) Splitting - $1.40/m^3; and

(e) Overheads and profit - $1.00/m^3.

Harvesting costs for regrowth pulpwood were estimated to total \$5.00/m^3 which was equal to the estimate for old-growth pulpwood less splitting costs since very little splitting of this wood would be necessary. While higher debarking, felling and snigging costs would be likely, it was considered that this would be compensated by the higher availability of pulpwood per hectare, lower defect, the likelihood of mechanical field debarking and chipping or based on the findings of Watson et al., (1974), the probability of no debarking at all.

The cost of \$4.50/m^3 adopted for harvesting radiata pine pulpwood (see Chapter 5) was assumed for fast-grown eucalypt pulpwood plantations.

Complete details of harvesting and haulage costs are provided in Appendix 12.1.

The basic harvesting cost for old-growth pulpwood (\$6.35/m^3) in some Management Areas was increased by 30 to 60 cents/m^3, depending on steepness of slope and other topographical factors. Furthermore, harvesting costs for old-growth pulpwood forests on private property were increased by approximately ten percent to $7.00/$m^3$ to allow for increased overheads (supervision and marketing arrangements and negotiations) and higher costs associated with the transfer of plant and equipment.

<u>Pulpwood Stumpage Prices</u>

The average stumpage price for each category of pulpwood in each Management Area is presented in Appendix 12.1, expressed in both solid volume and gross (including defect) or standing volume. The standing volume prices were determined by assuming an allowance for defect and are net of marketing costs which were estimated to be equal to $0.11 per m^3.

A minimum rate was also assumed for all Management Areas and was based on the current system of pricing adopted by the Forestry Commission of New South Wales which is reported recently to have set a minimum royalty of $0.50/tonne or approximately $0.56/$m^3$ solid. This was deflated to 1972/73 prices by means of the consumer price index and after allowing for a defect of 20 percent <u>less</u> marketing costs of 11 cents/m^3, a minimum stumpage price of $0.21/$m^3$ was derived this was adopted for the

Management Areas indicated in Appendix 12.1. It is considered to reflect the willingness to pay of the chipmill for additional quantities of pulpwood over and above existing supply commitments.

STUMPAGE PRICES FOR SAWLOGS FROM EUCALYPT FORESTS

The market for sawlogs from the eucalypt forests is much the same as that described for radiata pine in Part I. Sawmillers are able to influence the prices charged by the Forestry Commission through their trade association and many possess some degree of monopoly power over prices for timber harvested from private property. The residual value pricing procedure was again used rather than the appraisal system used by the Forestry Commission of New South Wales. By doing so, it was possible to take into account, firstly, any additional revenue arising from the sale of residue material, particularly woodchips, which the pricing system applied by the Commission at the time of the appraisal did not incorporate; and secondly, the tariff on sawn timber imports.

Assumptions

1. Sawmill Location

In Chapter 9, a change in the structure of the existing sawmilling industry was assumed to take place at the end of the fourth planning period with the structure up to that time remaining the same as in 1972/73. This is an important assumption since it is proposed to assess stumpage prices for each Management Area on some pre-defined logical mill-site.

The logical mill-site for each Management Area was identified by means of a simple least-cost approach:

$$\text{Minimize } H_{ij} + C_j + S_j$$

where H_{ij} denotes the cost of haulage for sawlogs from Management Area i to each of its alternative mill sites j (in \$ per m^3 log volume);

C_j denotes the cost of chip haulage from each sawmill site j to the chipmill at Edrom (in \$ per m^3 log volume);

and S_j denotes the cost of haulage for sawn timber from each sawmill location j to the key-market (in \$ per m^3 log volume).

No consideration was given to the total availability of sawlogs in each Management Area, nor to the sawlog requirements for each sawmill. Furthermore, the actual location of the sawmill frequently does not correspond with the least-cost location. Nevertheless, this is the basis of stumpage appraisal adopted by most State forestry authorities in Australia and has been accepted generally by industry.

The logical mill site for each Management Area during the first 20 years of the planning horizon was selected from the eleven major milling centres in the Region at the present time - Bateman's Bay, Bega, Bodalla, Cobargo, Eden, Moruya, Narooma, Nerrigundah and Ulladulla/Milton on the coast, and Bombala and Nimmitabel on the Tablelands. The logical mill sites for each Management Area are shown in Appendix 12.2.

For the remainder of the planning horizon, the estimated sawlog availability and the minimum annual capacity of new sawmills (following restructuring) of 16,521 m^3 per annum sawn were taken into account. Since it was estimated that only six sawmills could be sustained at this level, possible sites were considered to be Ulladulla/Milton, Bateman's Bay, Bodalla, Cobargo, Eden and Nimmitabel. The logical mill site for each Management Area shown in Appendix 12.2 for planning periods 4 to 9 was again based on the above least-cost formula.

2. Markets for Sawn Timber

A high level of utilisation is achieved by the Region's sawmills. Mills situated along the coast in the northern part of the Region achieve high sawn recovery through the conversion of material normally considered to be waste into dunnage and pallet timbers; those in the south and in the coastal and Tableland areas, have installed chippers for conversion of waste material into chips which are sold to the chipmill at Edrom.

It was found that, if sawn production from waste material for lower value products such as dunnage is disregarded, some 70 percent of the remaining output from sawmills in the coastal areas is sold to the building industry in Sydney and Port Kembla-Wollongong, some 20 percent locally, in the Australian Capital Territory and Melbourne, and the balance as industrial timber in the Port Kembla-Wollongong area. The Tableland sawmills at Bombala and Nimmitabel dispose of most of their production in the Australian Capital Territory.

For simplicity Sydney was chosen as the key market for stumpage pricing purposes not only because of its dominance but again because of the relatively competitive market for sawn timber there. This is a conservative basis because it ignores the higher-priced Canberra and local markets. Furthermore, the additional <u>sawn</u> timber recovered from residues by mills in the northern part of the Region (e.g. dunnage) was not taken into account in the pricing equation.

3. Marginal Changes in Prices

Changes in the supply of hardwood sawn timber were again assumed to be insignificant over time and therefore existing prices for inputs and outputs could be used. In view of the rationing carried out by the Commission under its log quota system, this assumption is probably quite realistic.

The Price Equation

The equation used to determine stumpage prices for sawlogs from eucalypt forests is similar to that used for radiata pine:

$$P_j = (S + C_{ij} - H_i - M)R - L_{ij}$$

where P_j denotes the stumpage price for sawlogs harvested from eucalypt forests in the j'th Management Area (\$ per m^3 log volume including defect);

S denotes the price for hardwood sawn timber (\$ per m^3 sawn);

C_{ij} denotes the value of woodchips recovered from sawmill residues at the i'th logical mill site from the j'th Management Area (\$ per m^3 sawn);

H_i denotes the cost of freight and transfer for sawn timber from the sawmill utilizing logs from the j'th location to merchant's yard (\$ per m^3 sawn);

M denotes the cost of sawmilling (\$ per m^3 sawn);

R denotes the proportion of sawn timber recovered (m^3 sawn per m^3 log volume); and

L_{ij} denotes the cost of logging for sawlogs from the j'th Management Area to the logical mill site i (\$ per m^3 sawn).

The main difference between this and the radiata pine sawlog pricing equation is the absence of any provision for log size. It was assumed that the range and distribution of log sizes would not vary greatly between Management Areas.

Sawn Timber Prices

The market price for hardwood sawn timber in Sydney was derived, firstly, by estimating the trend value in 1972/73 for real wholesale prices for hardwoods over the period 1953/54 to 1972/73; secondly, by adjusting for the list prices which were used to estimate the trend value to actual market prices; and thirdly by deducting trade discount, selling commissions and the cost of the tariff for comparable imports. This provides the free-in-yard price of hardwoods in merchant's yard in Sydney.

The prices for Framing and General Building Grades in Random Lengths, 1.8 to 6.4 metres, and in sizes 125 mm x 25 mm to 100 mm x 75 mm, from the Recommended Wholesale Price Lists of the Associated Country Sawmillers of New South Wales were used to estimate the trend value.

Where more than one price applied to any year, an average price was calculated by weighting each price by the period to which it applied during the year. These were then expressed in constant 1972/73 values by means of the Consumer Price Index for all commodities. The slope of the trend equation fitted to these prices by least squares regression was not significantly different from zero and therefore the mean price of $89.92/m^3 for the whole period was adopted for the sawn price, S.

A reduction of 4 percent was applied to equate the list price with the true market price. This was based on industry opinion. Trade discount of 2½ percent and selling commission of 6¼ percent were also allowed. A deduction of $4.24/m^3 was made for import duty and based on imports of Douglas fir flitches and baulks from North America. The free-in-yard price for hardwoods so derived was $74.66/m^3.

Cost of Sawmilling (M)

The eleven logical mill sites adopted for planning periods 0 to 3 account for more than 70 percent of the total output from the Region and average between 5,000 and 6,000 m^3 sawn per annum. Nine are located within the Region and although the other two are situated outside, they draw most of the log requirements from the Region's forests.

The two largest sawmills are located at Bombala and Eden; the latter having an annual log intake in excess of 30,000 m^3 excluding defect. Nevertheless, costs were based on the minimum average mill capacities anticipated in the two sub-horizons; these were assumed to be 5,360 m^3 sawn in planning periods 0 to 3 and 16,521 m^3 sawn in subsequent planning periods.

TABLE 12.2

Estimated cost of production of two hardwood sawmills

Item of Expenditure	Cost in 1972/73 $	
	Sawn Capacity 5,360 m^3	Sawn Capacity 16,521 m^3
A. Fixed Costs		
a. Administrative	21,000	65,000
b. Insurance	2,475	9,412
c. Depreciation	16,567	66,167
d. Return on capital investment	18,562	78,087
e. Interest on working capital	4,900	14,000
	63,504	232,666
B. Variable Costs		
a. Direct labour	73,080	116,928
b. Indirect labour	14,616	23,386
c. Other manufacturing	25,000	74,345
Total Expenditure	176,200	447,325
C. Average Cost of Production ($/cu.m)	32.9	27.1

The costs estimated for mills of these sizes are presented in Table 12.2 and the basis on which they were calculated is described in Appendix 12.3. The average cost per m^3 sawn for the sawmill of 5,360 m^3 capacity was $32.9 and for 16,521 m^3 capacity, it was $27.1.

On the whole, these are considered to be conservative because of the liberal provision for return on capital invested, depreciation rates, interest on working capital and in particular the relatively high wage rates adopted.

The Value of Sawmill Chips (C_j)

As for radiata pine, a deliberately conservative approach to the residual value method of pricing sawmill chips was again adopted, using the following equation:

$$C_i = ((P - H_i - G)\ B.\ R) \qquad (12.2)$$

where C_i denotes the value of chips produced at each sawmill i ($ per m^3 sawn);

P denotes the delivered price of chips to the chipmill at Edrom ($ per m^3 solid);

H_i denotes the cost of haulage from sawmill i to Edrom ($ per m^3 solid);

G denotes the cost of chipping and bin storage at the sawmill ($ per m^3 solid);

B denotes the green density of the wood chipped (tonne per m^3 solid); and

R denotes the volume of useful wood recovered as chips in m^3 for every m^3 of sawn timber produced.

TABLE 12.3

Residual values of sawmill chips at various sawmill locations expressed in $ per cubic metre of sawn production

Sawmill Location	Planning Period	Cost ($/tonne net)	Residual Value of Chips		
			$ per net tonne	$ per gross tonne	$ per m^3 sawn
Bateman's Bay	1995 to 2024	9.10	0.82	0.78	0.54
Bega	1975 to 1994	3.70	4.37	4.15	2.88
Bodalla	1975 to 1994	7.30	0.77	0.71	0.51
	1995 to 2024	7.30	2.62	2.49	1.73
Bombala	1975 to 1994	3.70	4.37	4.15	2.88
	1995 to 2024	3.70	6.22	5.91	4.10
Cobargo	1975 to 1994	5.10	2.97	2.82	1.96
	1995 to 2024	5.10	4.82	4.58	3.18
Eden	1975 to 1994	1.60	6.47	6.15	4.27
	1995 to 2024	1.60	8.32	7.90	5.48
Narooma	1975 to 1994	6.80	1.27	1.21	0.84
Nerrigundah	1975 to 1994	8.00	0.07	0.07	0.05
Nimmitabel	1975 to 1994	6.60	1.47	1.40	0.97
	1995 to 2024	6.60	3.32	3.15	2.18

The first part of the equation $(P - H_i - G)$ represents the value of sawmill waste per green tonne of chips. The parameter B, is used to convert this value into the value of sawmill waste per m^3 solid volume of chips and R converts this value into solid volume of pulpwood.

A description of the basis for estimating the chip values is presented in Appendix 12.4. A delivered price of $12.14/green tonnes was calculated for chips at Edrom by deducting 5 percent losses for storage and handling and an estimated $2.15 for wharfage, chip handling, overheads and profit.

The derived values are shown in Table 12.3 for each sub-horizon, planning periods 0 to 3 and 4 to 9. The most interesting feature is the distance over which chips could be profitably hauled and this increased with the size of the sawmill involved.

Sawn Recovery Factor (R)

In Appendix 12.3 the average recovery is shown to be 0.57 m^3 sawn per m^3 gross log volume based on data for sawmills in the Shires of Eurobodalla, Imlay and Mumbulla and the municipality of Bega in 1968/69. A recovery of 0.50 m^3 sawn was adopted to allow for the lower priced material such as dunnage included in this.

<u>Logging Costs (L_j)</u>

Harvesting costs which consist of felling, debarking (where required), butting, lopping and snigging were based on estimates supplied by local forestry and sawmilling personnel. In determining these costs, it was necessary to take into account:

(a) whether logging was integrated with pulpwood operations;

(b) the topographical characteristics of the area being logged (the Management Area);

(c) accessibility and road standards; and

(d) average snigging distance.

To simplify the estimation of felling and snigging costs for each Management Area, costs were classified according to the categories shown in Appendix 12.5. The estimated cost per m^3 under each category is also included in this Table

Haulage costs were based strictly on the gross haulage schedule as at 1 July 1973 in the Economics and Marketing Bulletin of the Forestry Commission of New South Wales.

Stumpage Prices

Using the values for various parameters in pricing equation, the stumpage prices for each Management Area were calculated and are shown in Appendix 12.6. These are slightly higher than those based on the Commission's assessments for the same areas but this is attributed primarily to the inclusion of chip values. For example, the average sawlog value for East Boyd Management Area was assessed at \$4.96 per m^3 by the Forestry Commission (Davies et al., 1974) which is \$2.76 per m^3 less than the value derived by means of the pricing equation of planning periods 0 to 3.

This difference is approximately the same as the value added by chips of \$2.74/m^3 log volume recovered from waste material at the sawmill at Eden. Overall the prices derived are therefore considered to be a reasonable estimate of the true social price of sawlogs in the Region.

PRICES FOR MINING TIMBER

It was not possible to identify the true nature of themarket for mining timber in the Lower South Coast but one suspects that it is well removed from the model of perfect competition. Although there is more than one buyer located in the coal fields in the Wollongong region, it is doubtful that strong competition between these buyers exists. There is also evidence that the Forestry Commission of New South Wales operates as a price leader in relation to stumpage price. Most of the mining timber operations are controlled by a small number of large contractors who deal directly with the mining companies.

In the absence of suitable data, however, it was decided to base the prices for mining timber on the appraisal system for mining timber used by the Forestry Commission of New South Wales. Furthermore, because of variation in these prices within any one supply area owing to the effect of a number of factors such as topography, slope, yield per hectare, piece sizes, and access, many of which could not be assessed from the information available, a simple average was estimated for each supply area. Since mining timber operations were assumed to be restricted to areas of less than 20° slope in the Mining Timber and Transition Supply Zones, the cost of extraction (felling, cutting to size, debarking and snigging) was considered to be relatively constant between Management Areas and therefore the only variable of relevance was the cost of haulage to the coal fields.

Four groups of Management Areas were identified in these two Supply Zones for stumpage pricing of mining timber: (i) Bateman's Bay and (ii) Narooma Sub-Districts of the Forestry Commission (iii) Mumbulla-Murrah Management Areas, and Brown Mountain Management Area. The average stumpage prices adopted for these four areas are presented in Table 12.4.

TABLE 12.4

Average stumpage prices for mining timber in four supply areas in the Mining Timber and Transition Supply Zones

	Supply Area	$/m^3
1.	Bateman's Bay Sub-District	3.00
2.	Narooma Sub-District	2.50
3.	Mumbulla-Murrah Management Areas	1.50
4.	Brown Mountain Management Area	0.50

Average stumpage prices for the Bateman's Bay and Narooma Sub-Districts were based on actual averages reported by the Forestry Commission in 1972/73, and these were used as the basis for extrapolating stumpages for mining timber in the other two areas where only small quantities have been logged in the past. However, the latter two areas were reported to be seriously consider as prospective sources of supply by mining contractors.

PRICES FOR PULPWOOD AND SAWLOGS FROM
RADIATA PINE PLANTATIONS IN THE
BOMBALA PLANTATION WORKING CIRCLE

As pointed out previously in this Chapter, shadow prices for pulpwood and sawlogs from radiata pine plantations were based on the same principles as those used in Part I in this investigation and further details of these principles are not considered necessary. The hypothetical sawmill was assumed to be located at Bombala, with the mill assumed to start up in 1995/96 on a one-shift per day basis and to change to two-shifts per day operation in year 2005/6. The main outlet for pulpwood was again assumed to be the chipmill at Edrom up to and including year 1994/95 (pre-1995/96) and the kraft pulpmill at Edrom from 1995/96 onwards.

Shadow prices estimated for the Management Areas in the Bombala Plantation Working Circle (Bondi Crown, Coolangubra, Glenbog, Tantawanglo and White Rock) are presented in Table 12.5.

TABLE 12.5

Prices for Pulpwood and Sawlogs from Radiata Pine Plantations in the Bombala Plantation Working Circle in $ per cubic metre

Product and D.b.h. Class	Bondi Crown	Coolangubra	Glenbog	Tantawanglo	White Rock
1. Pulpwood (Pre-1995/96)	0.77	0.39	0.00	0.25	1.23
2. Pulpwood (1995/96+)	4.61	4.23	3.35	4.09	5.07
3. Sawlogs (1995/96 to 2004/5)					
Less than 30 cm d.b.h.	11.68	12.04	10.96	11.84	11.56
30 to 35 cm d.b.h.	14.46	14.82	13.74	14.62	14.34
35 to 40 cm d.b.h.	18.32	18.68	17.70	18.48	18.20
40 to 50 cm d.b.h.	19.27	19.63	18.55	19.43	19.15
50+ cm d.b.h.	19.93	20.29	19.21	20.09	19.81
4. Sawlogs (2005/6+)					
Less than 30 cm d.b.h.	13.66	14.02	12.94	13.82	13.54
30 to 35 cm d.b.h.	16.70	17.06	15.98	16.86	16.58
35 to 40 cm d.b.h.	20.80	21.16	20.08	20.96	20.68
40 to 50 cm d.b.h.	21.90	22.26	21.18	22.06	21.78
50+ cm d.b.h.	22.67	23.03	21.95	23.83	22.55

GENERAL COMMENTS

With the exception of mining timber, shadow prices for wood products were estimated by means of the residual value method. However, unlike the shadow prices for radiata pine sawlogs, the prices which were derived for eucalypt sawlogs were not significantly greater than those prevailing in the Region based on Forestry Commission's appraisal system. The main difference is probably due to the inclusion of the value of sawmill chips which were estimated to be as high as $5-48 per m^3 sawn for the sawmill at Eden after the assumed restructuring of the sawmilling industry in 1994/95. The closer the sawmill was located to the chipmill/pulpmill, the higher these values became. It is now understood that provision is being made to incorporate these values in the Commission's appraisal system. Therefore the prices in this study should not differ much from those based on the Commission's appraisal system.

Shadow prices for pulpwood on areas located near the chipmill are much higher than those agreed to in the Pulpwood Agreement while on the other hand they are lower in more isolated areas.

At the present time, the stumpage prices being charged for sawlogs and pulpwood by the Forestry Commission, on the average are probably not far removed from their true social value.

CHAPTER 13

OPTIMAL SOLUTIONS FROM THE LINEAR PROGRAMMING MODELS

INTRODUCTION

In Chapter 9, it was pointed out that, in formulating the linear programming study initially, considerable weight was given to the views of a number of local foresters and sawmillers that the hardwood sawlog resource would be cut out over a large part of the Region in 20 to 40 years' time. On this basis, there seemed to be considerable scope for progressive conversion of marginal farmland to softwood plantations in order to supplement future sawlog supplies from the existing and future programme of planting on Crown land. Preliminary results from the linear programming models showed, however, that the hardwood resource was capable of supplying a greater volume of sawlogs than had been thought possible, for the next 50 years at least.

In the light of these results, it was necessary to reformulate the problem somewhat. Models R1 and R2 were treated as mutually exclusive proposals. In essence, the question underlying this treatment was whether further softwood planting in the Region should be continued, as planned, on Crown lands in the Bombala Sub-District (R1) or whether planting should be shifted entirely to conversion of marginal farmland (R2). While this treatment is something of an oversimplification, it does highlight the major policy issue.

Complete details of the results for the two models have been reproduced on microfiche and are included in Appendix 13.1. These details include the optimal sets of management strategies, the activity levels for each constraint in the optimal solutions, and the optimal values of the objective function. Thus this chapter will focus on summaries of the most important features of the results and a discussion of them.

MANAGEMENT STRATEGIES

Although the optimal strategies for softwood planting in the two models are more relevant to the main policy issue, some consideration must be given to the optimal strategies for native forests.

Strategies for Native Forests

Although there were some minor differences in rotation lengths between the two models insofar as the even-aged strategies in the Pulpwood and Transition

Supply Zones were concerned, virtually the same set of strategies were selected in the two models. The same strategies were initiated within the same planning period in the same Management Area.

The main strategy selected in the Pulpwood Supply Zone was strategy N (heavy cutting with minimum improvement). Rotation lengths were mostly 30, 40 or 50 years of which the 40 year rotation was the most common. The more intensive strategies, strategies E (clearcut and fully-stocked) and I (intensive plantation management), were not chosen at any stage in any Management Area.

No comment is needed in relation to Management Units exceeding 20^0 slope in the Pulpwood Supply Zone since only one strategy, strategy G (heavy cutting over two cutting cycles), was permitted on these slopes; nor is it considered necessary in relation to the Sawlog Supply Zone where only strategy S (extensive selection management) was specified.

As in the Pulpwood Supply Zone, the least intensive strategy, strategy S, was used almost universally throughout the Mining Timber Supply Zone. However, strategy Q (intensive selection management) was required in North Kioloa, South Kioloa and Bodalla Management

Areas and strategy T (mining timber only) was operated in North and South Kioloa Management Areas as well as Quartpot Management Area.

The widest range of strategies occurred in the Transition Supply Zone. In model R1, both strategy N, a pulpwood strategy, and strategy S, primarily a sawlog strategy, were selected in Brown Mountain Management Area and strategy S in the other two Management Areas. Other Management Areas in this Zone used strategy S.

In model R2, strategy N was not implemented in Murrah Management Area at all whereas Brown Mountain Management Area relied almost entirely on strategy N. Strategies selected for the remaining Management Areas in this Zone were identical to model R1.

In general, the schedule of cutting, both spatially and over time, followed the logical pattern, starting in the most productive areas with the highest present net worths and proceeding in this manner until some constraint became binding. A small number of strategies included in the optimal set had negative present net worths in order to satisfy some of the constraints imposed on the two models - in particular, in Brown Mountain, Glenbog and Tantawanglo Management Areas.

The reason for the inclusion of these strategies was discussed earlier but it should be noted that the number included in the optimal solution was small and would have little impact.

Radiata Pine Plantation Strategies

Table 13.1 shows the various strategies and their areas scheduled in the optimal linear programs computed for the two models.

TABLE 13.1

Schedule of management strategies for radiata pine plantations and their areas in hectares per annum for models R1 and R2

Planning Period	Model	Strategy A (Pulpwood only)		Strategy B (Pulpwood/sawlog)			Strategy C (Mainly sawlog)		
		15 yrs	20 yrs	30 yrs	35 yrs	40 yrs	30 yrs	35 yrs	40 yrs
0	R1	-	907	-	-	-	526	170	230
	R2	-	1,123	-	-	-	555	14	-
1	R1	-	1,131	-	-	-	-	-	536
	R2	-	1,176	-	-	-	-	-	536
2	R1	-	380	-	-	1,953	-	-	-
	R2	-	589	-	-	3,170	-	-	-
3	R1	-	-	-	2,000	-	-	-	-
	R2	-	1,312	-	4,016	-	-	-	-

All these management strategies, strategy A, B and C, featured among the set of strategies computed in the optimal linear programs for models R1 and R2. However, strategy A (pulpwood only) required the 20-year rotation only, strategy B (pulpwood/sawlog) the 35 and 40 year rotations, and strategy C (mainly sawlog) all three rotation lengths.

In model R1, strategies A and C were scheduled for start-up in planning periods 0 and 1, strategies A and B in planning period 2 while strategy B was the only strategy scheduled for planning period 3. The same pattern was found in model R2 except that strategy A was also extended into planning period 3. It should be noted that by scheduling Forestry B for start-up in planning periods 2 and 3, clearfellings from it do not enter the linear programming problem.

All Management Units in model R1 were scheduled for planting. Strategy A was restricted to Bondi (Crown) and White Rock Management Areas, strategy B to all areas other than Tantawanglo and strategy C to Bondi (Crown) and Coolangubra Management Areas only.

Eight out of the ten Management Areas in the farmland were planted in model R2. Strategy A was undertaken in Bondi (Private), Burragate, Nungatta, Pambula and Wyndham Management Areas; strategy B in Bega and Candelo Management Areas; and strategy C in only Cobargo Management Area. All available farmland was planted in Bega, Burragate, Bondi (Private), Nungatta and Pambula Management Areas but no planting was carried out at all in Bemboka and Lower Brogo Management Areas. Well over half the area of farmland in Candelo Management Area (2,686 ha out of 4,500 ha) was planted and just under one-third was planted in Cobargo (1,106 ha out of 3,780 ha) and Wyndham (348 ha out of 1,332 ha) Management Areas.

One of the most distinctive features of the optimal solutions for both models was the role played by strategies involving pulpwood production only. This highlights the importance of the assumptions made regarding pulpwood markets. Although it seems unlikely to affect the comparative results, further investigation of alternative assumptions about pulpwood markets are needed.

TABLE 13.2

Volumes (in m^3 per annum) computed for demand constraints for pulpwood, sawlogs and mining timber in optimal solutions for models R1 and R2

Planning Period	Pulpwood Demand (DPULP)		Sawlog Demand (DSAW)		Mining Timber (DMINT)	
	R1	R2	R1	R2	R1	R2
0	700,000*	700,000*	289,420	256,310	30,000**	30,000**
1	700,000*	700,000*	281,150	252,850	30,000**	30,000**
2	700,000*	700,000*	311,610	300,000**	30,000**	30,000**
3	700,000*	700,000*	300,000**	300,000**	30,000**	30,000**
4	1,189,000	1,214,100	400,000**	400,000**	30,000**	30,000**
5	1,286,900	1,378,900	400,000**	400,000**	30,000**	30,000**
6	1,117,000**	1,382,100	472,000*	472,000*	30,000**	30,000**
7	1,117,000**	1,368,100	496,000*	496,000*	42,096	40,144
8	1,302,400	1,117,000**	521,000*	521,000*	45,000*	45,000*
9	1,117,000**	1,117,000**	548,000*	532,230	45,000*	45,000*
Total	9,929,300	10,377,200	4,019,180	3,930,390	342,096	340,144

Footnote: * - upper limit

** - lower limit

DEMAND CONSTRAINTS

Lower and upper limits were specified for the constraints on the demand for pulpwood (DPULP), sawlogs (DSAW) and mining timber (DMINT). The values computed in the optimal solutions for each of these constraints are presented in Table 13.2.

Demand for Pulpwood

The upper limit of 700,000 m^3 was binding on both models in planning periods 0 to 3 but from planning period 4 onwards either no restriction existed or the lower limit was binding. Model R2 produced slightly more pulpwood than model R1 during the planning horizon but the difference was of little significance.

Where demand was binding i.e., where the upper or lower limits specified for demand were reached, dual prices (labelled "dual activity" on output in Appendix 13.1) were quite small and always less than \$1 per m^3. The upper limits were binding during the early planning periods but this later switched to the lower limits. The relatively small dual prices indicated that the limits as defined were satisfactory and that no major change was needed.

Demand for Sawlogs

Model R1 produced a larger volume of sawlogs than model R2 over the whole planning horizon but only marginally so. This constraint was not binding until planning period 3 in model R1 and planning period 2 in model R2 when both models became binding on the lower limits. However, since the lower limits represented the minimum requirements for the sawmilling industry, there were not any grounds to reduce them.

From planning period 6 onwards, the Region has sufficient capacity to satisfy most of its anticipated demand for sawlogs with the upper limit eventually preventing any further expansion in production. These upper limits were associated with quite high dual prices which were noticeably much higher in model R2. The largest dual prices were generated in planning periods 6 and 7, reaching, in planning period 6, \$11.17 per m^3 in model R2 and \$6.84 in model R1. However, since the upper limits were based on recent estimates of the future growth in sawlog demand for Australia, there seemed to be little justification for raising them without having a better basis for predictions of Regional sawlog demand.

Demand for Mining Timber

Very little difference exists between the two models in the total volume and time-scheduling of mining timber produced from the Region. This constraint was binding on its lower limit during planning periods 0 to 6 but it switched to its upper limit in planning periods 8 and 9.

However, dual prices in planning periods 0 and 1 were high in both models, reaching \$16 and \$18 per m^3 in the case of the R2 model. This suggests that the scope for mining timber production in the Region may be more limited than hitherto believed. Nevertheless, commitments to the mining industry are such that the lower limits seem the lowest practicable level. Further investigation of other sources of supply and/or increases in the price of stumpage seem warranted.

SUPPLY CONSTRAINTS - NATIVE FORESTS

Pulpwood from Crown Lands

Two types of constraints were recognized in this category: firstly, the maximum level of commitment from these forests by the Forestry Commission for which lower and upper limits were specified (designated PULPEC) and secondly, the minimum levels of pulpwood required from specific blocks of Crown lands within the Pulpwood and Transition Supply Zones (designated HPULPA, HPULPB and HPULPC). The values computed for these four constraints in the optimal solutions for the two models are presented in Table 13.3.

TABLE 13.3

Volumes (in m^3 per annum) computed for constraints relating to pulpwood supply from native forests on Crown lands

Planning Period	PULPEC		HPULPA		HPULPB		HPULPC
	R1	R2	R1	R2	R1	R2	R1 and R2
0	580,000*	580,000*	241,660	295,000	100,000**	100,000**	55,000**
1	580,000*	559,760	258,330	263,080	100,000**	105,180	55,000**
2	580,000*	580,000*	191,670	261,660	100,000**	124,880	55,000**
3	580,000*	547,010	178,210	100,000**	146,790	265,590	55,000**
4	548,480	548,340	100,000**	100,000**	381,020	340,260	55,000**
5	520,000**	520,000**	100,000**	100,000**	352,630	306,500	55,000**
6	580,000*	580,000*	387,750	377,150	125,550	127,300	55,000**
7	580,000*	580,000*	184,080	162,920	329,220	336,080	55,000**
8	552,440	580,000*	314,440	149,150	183,000	229,920	55,000**
9	520,000**	580,000*	268,780	227,560	185,560	100,000**	55,000**
Total	5,620,920	5,655,110	2,224,920	2,036,520	2,003,770	2,035,710	550,000

Footnote:- * - upper limit

** - lower limit

(a) The PULPEC Constraint

The range between the lower (520,000 m^3) and upper (580,000 m^3) for this constraint is relatively small and the dual prices computed were also small. The upper limit was based on the agreement between the Forestry Commission and the Daishowa Inc. Ltd, and thus there seems little scope for improving the value of the optimal solution by changing these limits.

(b) HPULPA, HPULPB and HPULPC Constraints

The Management Areas contributing to the HPULPA and HPULPB constraints produced four times as much pulpwood as those contributing to HPULPC. The lower limit of 55,000 m^3 for HPULPC was binding throughout the planning horizon whereas in the case of HPULPA (100,000 m^3) it only became binding during the intermediate planning periods and during the early planning periods in the case of HPULPB (100,000 m^3). More pulpwood was produced from the HPULPA Management Areas in model R1 than in model R2 but this probably reflects action of other constraints. In general dual prices were quite small and therefore there was little more to be gained in reducing the lower limits further.

Pulpwood from Private Property

The volumes computed for this constraint (PULPEP) are presented in Table 13.4.

TABLE 13.4

Volumes (in m^3 per annum) computed for constraints relating to pulpwood supply from private property (PULPEP)

Planning Period	R1	R2
0	120,000	120,000
1	120,000	133,800
2	120,000	120,000
3	104,960	130,160
4	165,070	126,070
5	70,688	71,080
6	51,207	50,000**
7	70,045	50,000**
8	50,000**	52,451
9	69,427	149,070
Total	941,397	1,002,631

Footnote:- ** - lower limit

The lower limit of 50,000 m^3 was exceeded in all planning periods except planning period 8 in model R1 and planning periods 6 and 7 in model R2. Because the dual prices associated with the constraints were quite small, there were no reasons to reduce these lower limits. Model R2 produced more pulpwood from this source than model R1 but the difference was marginal. As expected, production was highest in both models in planning periods 0 to 4.

TABLE 13.5

Volumes (in m^3 per annum) computed for constraints relating to sawlog supply from native forests on Crown lands in the South East Forestry District

Planning Period	QSAWBE		QSAWBM		QSAWED	
	R1	R2	R1	R2	R1	R2
0	40,000*	40,000*	27,501	20,000**	34,616	39,959
1	40,000*	40,000*	25,000**	20,000**	36,916	37,294
2	40,000*	40,000*	35,000*	20,000**	30,370	40,452
3	40,000*	40,000*	30,000*	19,360	33,512	35,000**
4	40,000*	40,000*	1,800**	8,000*	45,000*	44,562
5	40,000*	40,000*	1,800**	9,000*	45,000*	38,523
6	35,000**	35,000**	1,800**	4,000**	30,000**	30,000**
7	35,000**	35,000**	1,800**	4,000**	30,000**	30,000**
8	36,785	40,000*	1,800**	4,000**	3,000**	3,000**
9	40,000*	40,000*	3,440	4,000**	4,555	3,000**

Footnote:- * - upper limit

** - lower limit

Sawlogs from Crown Lands

Seven constraints were identified under this broad grouping. QSAWBB constrains the quantity of sawlogs that must be supplied from the Batemans Bay Sub-District excluding North and South Kioloa Management Areas which together were designated QSAWKI; similarly QSAWBE constrained the quantity of sawlogs from the Bega Sub-District; QSAWBM from the Bombala Sub-District; QSAWED from the Eden Sub-District; QSAWNA from the Narooma Sub-District excluding Bodalla Management Area which was designated QSAWBO. The lower levels defined in Chapter 9 were not treated as inflexible and were increased wherever possible, the aim being to sustain a reasonably constant level of output over the whole planning horizon at the highest rate possible.

These seven constraints were discussed under two broad groupings, those belonging to the South East Forestry District (QSAWBE, QSAWBM and QSAWED) and those belonging to the South Coast Forestry District (QSAWBB, QSAWBO, QSAWKI and QSAWNA).

(a) South East Forestry District Constraints

The volumes computed for these constraints are presented in Table 13.5. The main feature of Table 13.5 is the tendency of QSAWBE to be binding on both models at the upper limit of 40,000 m^3 throughout the planning horizon. Therefore it would appear that the upper limit could have been increased particularly in model R2 in planning periods 2 to 5 where dual prices from \$8.5 to \$10.1 per m^3 were generated. However, no increase was introduced because this constraint was also binding on the lower limit of 35,000 m^3 in planning periods 6 and 7 which also generated relatively high dual prices.

In contrast, the other two constraints, QSAWBM and QSAWED, were typically binding at these lower limits. In model R2, the dual prices of \$22.5 and \$18.9 per m^3 computed for QSAWED in planning periods 6 and 7 were very high but because of the desire to maintain production from the Eden Sub-District at 30,000 m^3 which is about the level the Forestry Commission is committed to supply, no reduction was made. Dual prices were not nearly as high in model R1, the only exception being QSAWBM which generated dual prices of \$27.3 and \$26.5 per m^3 in planning periods 2 and 3 respectively.

Here, as elsewhere in these models, detailed consideration by local foresters is needed before attempting to "fine tune" the constraints to rectify minor problems of the kind noted above. Nevertheless, it is clear from the various results of this study that such changes would not affect the major policy results in relation to softwood planting.

TABLE 13.6

Values computed for constraints relating to sawlog supply from native forests on Crown lands in the South Coast Forestry District in m^3 per annum

Planning Period	QSAWBB		QSAWBO		QSAWKI		QSAWNA	
	R1	R2	R1	R2	R1	R2	R1	R2
0	25,000**	25,000**	7,825	8,089	60,000*	52,000**	50,000	50,000
1	25,000**	25,000**	8,486	8,486	52,000**	52,000**	50,575	48,825
2	30,000*	30,000*	9,000*	9,000*	52,000**	60,000*	55,000*	55,000*
3	30,000*	30,000*	9,000*	9,000*	52,000**	60,000*	55,000*	55,000*
4	30,000*	30,000*	9,000*	9,000*	52,000**	60,000*	55,000*	55,000*
5	30,000*	30,000*	9,000*	9,000*	52,000**	60,000*	55,000*	55,000*
6	25,000**	25,000**	7,500**	7,500**	52,000**	52,000**	45,000**	45,000**
7	25,000**	25,000**	7,500**	7,500**	52,000**	52,000**	45,000**	45,000**
8	30,000*	30,000*	9,000*	9,000*	52,000**	52,000**	55,000*	55,000*
9	30,000*	30,000*	9,000*	9,000*	52,000**	52,000**	55,000*	55,000*

Footnote:- * - upper limit

** - lower limit

(b) South Coast Forestry District Constraints

The values computed for QSAWBB, QSAWBO, QSAWKI and QSAWNA in the optimal solutions are presented in Table 13.6. In early runs of the two models, the dual prices generated for this group of constraints were so high that they could not be ignored. It was most apparent that by basing upper limits on existing commitments, the forests in this District would be seriously undercut and that major gains in the value of linear programs could be achieved by increasing these limits. Thus, the lower and upper limits for these constraints were raised until acceptable shadow prices were achieved while at the same time maintaining production at a constant level over the planning horizon.

QSAWKI and QSAWNA were the main constraints affected. The lower limits were raised by 30,000 m^3 to 52,000 m^3 in the case of QSAWKI and by 20,000 m^3 to 45,000 m^3 in the case of QSAWNA. The new upper limits adopted were 60,000 m^3 for QSAWKI and 55,000 m^3 for QSAWNA. Although the lower limit of QSAWBO was almost doubled by increasing it to 7,500 m^3 with an upper limit of 9,000 m^3, in terms of Regional supply, this was not nearly as significant in absolute terms as the increases applied to QSAWKI and QSAWNA.

In spite of these increases, dual prices remained high in some planning periods particularly in model R2.

Attempts to reduce these dual prices gave rise to higher dual prices in other periods, and hence the present set was adopted.

Sawlogs from Private Property

This constraint, designated PRISAW, was left free throughout the planning horizon, the main reason being to enable private property forests to take up slack as would be the case in practice.

SUPPLY CONSTRAINTS - SOFTWOOD PLANTATIONS

Two sets of sawlog constraints were employed, RLOGBM defining the effective set of constraints in model R1, and RLOGBE in model R2. One set of pulpwood constraints (PULPRF) was used in both models. These constraints were only operative for planning periods 4 to 9. The activity levels for these constraints in the optimal solutions are summarized in Table 13.7.

TABLE 13.7

Volumes (in m^3 per annum) computed for pulpwood and sawlog supply constraints for radiata pine plantations

Planning Period	RLOGBM (R1)	RLOGBE (R2)	PULPRF	
			R1	R2
0	-	-	-	-
1	-	-	-	-
2	-	-	-	-
3	-	-	-	-
4	130,120	80,000**	404,260	490,340
5	157,820	126,010	663,560	700,000*
6	275,700	273,500	479,510	700,000*
7	299,660	297,500	400,380	700,000*
8	300,000*	300,000*	700,000*	527,070
9	300,000*	300,000*	580,570	425,010

Footnote:- * - upper limit
** - lower limit

In the case of both sets of sawlog constraints, there was a relatively smooth progression in the activity levels of the optimum solution until the upper limit was reached in period 8. With the exception of the dual prices for RLOGBE in periods 8 and 9, which are of little concern to the main policy issue, the dual prices generated were small.

Pulpwood supply, on the other hand, did fluctuate rather widely, because of the gap between the upper and lower limits. Even so, the fluctuations were not of major consequence for the present study. Dual prices generated were small.

OTHER CONSTRAINTS

Loan Funds

The activity levels for the use of loan funds in the optimal solutions are summarized in Table 13.8. The values shown are based on the social costs involved, being values according to the shadow price on loan funds ($2.73 per dollar for the 5 percent discount rate).

TABLE 13.8

Loan funds(1) needed to finance the forestry programmes computed in the optimal solutions for models R1 and R2

Planning Period	Model R1	Model R2
0	2,064,900	1,917,000
1	2,276,700	2,134,200
2	2,726,200	3,178,500
3	2,693,600	4,200,000*
4	1,639,000	2,062,700
5	1,267,300	1,304,700
6	958,980	1,004,800
7	917,000	829,670
8	20,948	31,491
9	186,090	22,784

Footnotes:- (1) including the shadow price for loan funds of $2.73 per dollar

* upper limit

At no stage were loan funds limiting in model R1 and they were only limiting in period 3 in model R2. Even then, the dual price generated was very small.

The total amounts of loan funds required over all ten periods, with the shadow price removed, were $5.[illegible]4 million and $6.11 million respectively for models R1 and R2; the difference reflecting the larger area planted in model R2.

Planting Rates

The annual planting rates involved by the optimal solutions for periods 0 to 3 are summarized in Table 13.9.

TABLE 13.9

Annual planting rates in hectares computed for radiata pine plantations in planning periods 0 to 3 in the optimal solutions for models R1 and R2

Planning Period	Model R1	Model R2
0	1,833.4	1,692.8
1	1,666.7	1,711.9
2	2,333.3	3,758.8
3	2,000.0	5,328.4

On the basis of these planting rates, the total area of plantations established over the 20 years covering planning periods 0 to 3 would be as follows:-

Model R1 - 39,167 hectares

Model R2 - 62,460 hectares.

PRESENT NET WORTH

The present values of the net social benefits (designated LEV in Appendix 13.1) for the optimal solutions are presented in Table 13.10. The values are five times those shown in Appendix 13.1 because of the scaling of area to the length of the planning period.

TABLE 13.10

Present values of the net social benefits computed in the optimal linear programming solutions for models R1 and R2

Model	Present Values ($)
R1	94,600,000
R2	84,885,000

The present value for model R1 was $9.7 million greater than that for model R2, suggesting that the proposed programme of planting on Crown lands is to be preferred to the conversion of marginal farmland.

This comparison is weighted strongly in favour of model R2 in the sense that the total area which had to be planted was 23,000 ha larger than that for model R1 and this increases the present net worth of model R2 accordingly. As an arbitrary device to remove this difference, model R2 was re-run using upper limits on planting of 2,400 ha/year over the four periods (0 to 3) concerned. This reduced the area planted in R2 to 45,900 ha, a good deal closer to the 39,167 ha involved in model R2. The difference in the present values widened to $14.9 million but there were no other major changes in the optimal solution for model R2.

The results of further runs of model Rl and the original model R2, using a discount rate of six percent and appropriate adjustments to shadow prices for capital etc., yielded similar results. The magnitude of the difference reduced somewhat but nothing else of substance changed.

DISCUSSION

The principal bone of contention in accepting these results relates to the opportunity cost of native forest to be cleared for planting in the Rl model. Although an opportunity cost for land was incorporated, it was based on the opportunity cost derived from continued wood production. If the areas concerned are capable of yielding higher net social benefits from recreational, aesthetic and/or scientific use, then the results presented will overstate the present value for model Rl and understate them for model R2. In the latter model, most of the net social benefits derived from these other uses seem likely to be supplementary to the extensive form of wood production envisaged for the areas concerned.

There is, of course, no objective answer to this problem. The difficulty of estimating the net social benefit of these other uses is well known. No data which would assist in such an evaluation are available for the area in question. Nevertheless, based on the limited data available (Ferguson and Greig; 1973; Greig, 1974) for evaluation of net social benefits in vaguely similar situations, the magnitude of the difference in present values between the models seems likely to outweigh the effect of any revisions of opportunity cost for the 39,000 ha in question.

There may, of course, be scope for some reduction of the two planting programmes and integration of them. Consideration of this would require careful re-evaluation of the scheduling and siting of wood-based industries. Before investigating this possibility, however, further studies are needed into the entire pattern of industrial development, in the light of the results to hand. In particular, the future prospects for development of an export-oriented pulp mill warrant close scrutiny, because of the importance of pulpwood markets in these results.

CHAPTER 14

CONCLUSIONS

The Main Results in Brief

There are about 130,000 hectares of farmland in the Lower South Coast Region of which at least 70,000 hectares are considered to be marginal for farming. This was established by carrying out a broad-scale reconnaissance survey of the farming areas (Reilly et al., 1975) and using results from other surveys undertaken previously in the Region (for example, Brown and Hogg, 1973). With appropriate site preparation, the farmlands should be capable of achieving site index 24 to 27 metres under radiata pine plantations.

When compared with both dairying and beef grazing, radiata pine plantations were clearly more economic than either of these two forms of land use, irrespective of the assumptions relating to prices, costs and yields and regardless of the discount rate applied. Thus, there is scope for a large plantation undertaking in these areas.

The problems of the scale of such a project, its location and the strategies that would best fit the requirements of the project were examined by constructing an economic model of wood production for the whole Region. However, the native forests were found to be capable of producing a much greater volume of sawlogs than was originally thought possible, at least over the 50-year planning horizon adopted in this model. Therefore, rather than evaluate the role that plantations established in the farming areas might play in balancing supply and demand for sawlogs, two mutually exclusive models were constructed, one based on converting the native forests on Crown lands proposed for the Bombala plantation project (model R1) and the other based on converting the farmland to plantations (model R2). While this is an over-simplification of the problem, it does portray the main policy issue.

It was found that conversion of the farmland to softwood plantations was less attractive economically than conversion of the native forests in the Bombala plantation project and that this difference was magnified when the annual planting rate on the farmland was reduced to a level comparable with that proposed for the Bombala project.

The investigation used the principles of cost-benefit analysis. Thus social, and not private, benefits and costs were required. The criterion for comparing strategies was the present value of the net social benefits. Benefits and costs were discounted by means of the social rate of time preference for the social discount rate and was estimated to lie between 4 and 6 percent. The most likely value for this rate was considered to be 5 percent. Shadow prices were also computed for the various sources of capital used to finance operations. The shadow price for loan funds was $2.73 per dollar, and for other sources of funds, $1 per dollar.

While the estimates for the various parameters provide a starting point for social cost-benefit analyses, their shortcomings must also be acknowledged. Deficiencies in the data available necessitated sweeping assumptions at a number of important points. Further research is needed to clarify these points and to improve the basis of the estimates.

Implications of the Results

While the main objective to construct a suitable economic model of wood production for the Lower South Coast was successfully achieved, the model was used to evaluate only one major policy issue affecting the Region's forests and their management. Many other key issues, therefore, still remain unresolved. Although some changes to the existing data will be necessary, it is considered that they should not be significant in most cases and that the general model will provide an excellent vehicle with which to carry out these evaluations. Thus, it seems relevant to this study to make some observations on the possible outcomes to some of the more important remaining issues using as the basis the results already produced in this investigation.

(1) Inclusion of Farmland in Model R1

What would have been the outcome if planting of the farmland had also been permitted in model R1? To evaluate this, a completely new set of shadow prices would have to be recalculated for radiata pine sawlogs based on the sawmill at Bombala. Using these prices, the results seem obvious enough. Pulpwood production would be concentrated in plantations located in the farming areas close to the pulpmill while sawlogs would be mainly produced from the Bombala plantations because of their closer proximity to the sawmill at Bombala. The size of the Bombala plantation project would also be reduced considerably and the present value of the net social benefits for the optimal solution would be increased.

(2) Pulp for Export Rather Than Domestic Consumption

Would the position change if softwood pulp production from the pulpmill is exported overseas instead of sold in the domestic market as was assumed in the main investigation? Results from Part I of this study throw some light on this issue since the lower bound prices for pulpwood were based on prices for woodchip exports. Since negative present net worths were calculated for all farming areas considered in that analysis, there would seem to be little, if any, justification for growing softwood pulpwood in the Region. Certainly areas should not be used for pulpwood production only. The total area required for planting would also be reduced and would be used primarily for sawlog production. However, the native forests would have to satisfy the requirements of the pulpmill for pulpwood, but by careful rescheduling and by varying strategies, these forests should be more than capable of supplying these requirements.

(3) Reservation of Crown Lands for Purposes other than Wood Production

Some comment is also needed on the likely effect of reserving large areas of Crown lands exclusively for purposes other than wood production; e.g. as State or National Parks. The results would be very much dependent on the areas involved. Crown lands required for the Deua-Tuross National Park proposal have already been removed from the two models. However, because of the negative present net worths generated by the strategies used in these areas, their exclusion has improved rather than reduced the present values of the optimal solutions.

The problem becomes far more complex if large areas of Crown land are taken out of production in the Pulpwood Supply Zone. Within the Bombala plantation project area, the removal of the unplanted Crown lands in Bondi and Coolangubra Management Areas almost certainly would have contributed to the lower present value computed for model R2. On the other hand, the exclusion of Glenbog and Tantawanglo Management Areas would have induced the opposite effect because of the negative net present worths computed for these two areas - again in model R2.

The exclusion of other Management Areas in the Pulpwood Supply Zone would almost certainly have caused a reduction in the present value of the optimal solution but for areas outside the Bombala plantation project area, this would depend on the underlying assumptions and the model used. In model R1, providing planting of the farmland is permitted, there is unlikely to be any serious economic trade-off by excluding these areas. However, there would have to be some relaxation of the commitments for sawlogs and pulpwood from the native forests in order to arrive at a feasible solution. In model R2, the end result is less clear but one suspects that there would be little, if any, economic loss.

A Plantation Scheme for the Farming Areas

It will be apparent from the foregoing discussion that softwood plantations play an important role in the Region's wood supply and, in the case of plantations located on the farmlands, they have the potential to resolve many of the conflicts that have arisen over the use of forests in the Region. If, after considering all the facts, society prefers to scale down the Bombala plantation project or the woodchip project or both, while at the same time still requiring the Region to satisfy the demands for wood products anticipated in this study, there seems to be no alternative except to undertake a major plantation project in the farming areas.

There are many ways that such a scheme ought to be implemented but the following are considered to be the more important:-

(1) Acquisition of marginal farming areas by the Commonwealth or State governments through the purchase and amalgamation of existing farms with the State carrying out the planting programme.

(2) Acquisition of marginal farming areas by the private sector such as a public or private company, again through the purchase and amalgamation of existing farms. One company, Kapunda Development Co. Pty. Ltd. has already acquired a large area of freehold land for this purpose, both in the upper reaches of the Towamba River and on the Tablelands near Bombala.

(3) Acquisition of marginal farming areas as in (1) and (2) except that the scheme would be on a voluntary cooperative basis involving the farmers themselves and probably financed from rural reconstruction funds. A forestry cooperative would be set up among the farmers to buy the land and to provide the technical expertise for establishing and maintaining

the plantations and for marketing the wood products. Farmers would provide their labour to the project and they would be permitted to remain on their farms. This kind of scheme can assume many forms particularly in relation to membership and purchasing arrangements. On first sight, the scheme seems very appealing but the well-known problems associated with other farming cooperatives are certain to spill over into forestry. Many of the farmers are also approaching retirement and therefore would hardly be attracted by a long-term venture such as forestry. However, the fact that they can gain immediate income through sale or leasing of their land to the cooperative as well as providing them with employment, the scheme still has many attractions.

(4) Reconstruction of farm enterprise combinations including farm woodlots or integrated farming and forestry. The woodlot scheme does not seem to be attractive to many farmers except on a relatively small scale. However, the integrated approach holds considerable promise. The success of both alternatives will depend very much on the type of incentives offered to the farmer to change to forestry.

Many other schemes also exist including leasing arrangements and forestry investment companies, but in general they seem less appealing. On the basis of the results produced in this study, however, there seems to be little incentive for the Forestry Commission to undertake a large-scale land acquisition programme in the Region, and a cooperative scheme is fraught with practical problems. Thus, the implementation of a scheme on the farmland would seem to be restricted primarily to alternatives (2) and (4). Unless a powerful incentive scheme is introduced for farmers, the scale of planting in the farming areas will revolve around companies such as Kapunda Development Co. Pty. Ltd. and possibly in the long term, the woodchip company, Harris-Daishowa (Aust.) Pty. Ltd.

Opportunity Cost Based on Uses other than Wood Production

In the light of the discussion so far, and assuming that softwood pulpwood is not exported, the current proposals for forestry development in the Region may not be all that far removed from the optimal set of strategies. Of course, this ignores the one vital ingredient that has been omitted from this study, namely, the net social benefits generated by recreational, aesthetic, preservation and/or scientific uses associated with the various wood production strategies considered in this investigation. To simplify discussion, these uses are collectively labelled "intangibles".

Inclusion of an appropriate value for intangibles would not necessarily have changed the end results. These results indicated that the switch to planting farmland in order to preserve the intangibles associated with native forests in the Bombala plantation project area will involve a large trade-off in the present value of the net social benefits accruing to wood production from the Region. Whether a trade-off of this order can be justified is impossible to answer until the present value of the net social benefits stemming from these intangibles has been estimated.

There are reasons for thinking that this value may not be large. Firstly, there are much larger tracts of comparable forests in northern Victoria which would tend to reduce the magnitude of this value. Secondly, the forests in question have been subject to considerable modification through low intensity logging and bushfire. Thirdly, the Forestry Commission has not ignored intangibles in managing the forests under its control and in fact persues a vigorous policy of preserving and even enhancing these values in many areas, including the Lower South Coast. By adopting such a policy and by minimizing undesirable environmental effects in what are commonly referred to as "production" forests, the Commission may well be approaching an optimal strategy for the whole State and therefore the Region should be viewed in this context.

Nevertheless, doubts must continue to exist in the mind of the public about much of the forestry programme in the Lower South Coast as long as a value cannot be assigned to the opportunity cost of the intangibles, particularly in view of the fact that large areas of marginal farmland are available for planting there. Since so much hinges on this value, it is imperative that research into its valuation is stepped up dramatically.

Other Considerations

There are several factors which may explain why State governments have tended in the past to refrain from undertaking large land acquisition programms for forestry purposes. Probably the most important relates to finance. One advantage of undertaking the conversion of native forests to plantations in preference to farmland is that revenue is generated immediately through the sale of all usable timber prior to clearing operations. The problem of finding extra funds for land acquisition purposes must also be considered and in the long term the financial viability of these forests will be greatly enhanced as a result of raising their productivity.

When considered together, these three factors become particularly attractive to financially hard-pressed forest services faced with declining productivity in the native forests, including privately-owned land.

Political considerations and changing circumstances must also be taken into account. Many people overlook the fact that once converted to plantations, the farmland will be removed from agricultural production for many years - maybe indefinitely. For this reason, and the fact that the markets for agricultural products fluctuate greatly, farmers tend to resist changes to a land use which is characterized by inflexibility since this prevents them from taking advantage of high prices for agricultural products in more buoyant market situations. This factor, combined with the political overtones associated with implementing a large plantation project on farmland, must weigh heavily with politicians, particularly if land resumption rather than some voluntary scheme is involved.

Governments also find it difficult to comprehend why controversy should arise over relatively small areas of native forest. For example, in the Lower South Coast, native forests still make up some 800,000 hectares (or 75 percent) of the total land area and of this, about

5 percent is involved in the Bombala plantation project, and about 25 to 30 percent in woodchip project area.

The investigation also consists of a partial analysis, but the results are unlikely to have changed if the regional models had been integrated into a much larger model of wood production for the whole of Australia. The levels of demand specified in the Regional models for sawlogs and mining timber were closely tied to present and future Australian markets, and it is considered that the kraft softwood pulp to be produced from the pulpmill should be absorbed in the Australian market without too much difficulty. In fact, there is every liklihood that if the models had been viewed in the context of a supply-demand model for Australia, requirements from the Region could have been even higher because of its proximity to major markets and the relatively high potential productivity of much of its forests, particularly the radiata pine plantations in the Bombala project.

Should the woodchip project be terminated? There is no simple solution to this question. The project is already firmly established with many people dependent on it. Nevertheless, although it cannot be easily terminated, another option is available. It involves the commencement of planting on the farmland immediately with either radiata pine or eucalypt species (the economics of the latter do not appear to be very attractive) in order to build up a sufficiently large pulpwood resource to take over the role of the native forests in supplying pulpwood for the chipmill/pulpmill in about 20 years time. The economic trade-off of doing this is unknown, but if a large part of production is exported, then the trade-off is likely to be significant and even prohibitive.

An Overview

The investigation has clearly shown the value of examining wood production strategies at the regional level using a cost-benefit framework, particularly where serious conflict over the use of the forests exists. Such an analysis can provide policy-makers with the information that they so badly need in evaluating various policy options and as a result this must assist them in anticipating possible conflicts and providing solutions to them before they arise. The problem of constructing such models is imposing, however, as the author's experience with this study can confirm. This is particularly so where much of the necessary data is non-existent at the outset as was the case in this study. An enormous amount of data is needed as well as the back-up support of many specialists.

The investigation displayed only too clearly the lack of information on growth and yield for eucalypt forests and emphasised the need for greater research in this area. The yields calculated in this study are obviously subject to possible error but the extent is unknown. However, it is doubtful whether there would have been a significant change to the results using far more accurate data.

The derivation of shadow prices for inputs and outputs involved some simplifying assumptions about market prices and marginal social costs. Nevertheless, considerable attention was devoted to estimating shadow prices for those outputs or inputs where market prices were clearly not representative of marginal social costs. Further refinement of the remainder might be possible by a more detailed decomposition into wage, salary and capital components and separate adjustment of each component to reflect social values. However, such an exercise was outside the scope of this study. Moreover the results of various sensitivity tests suggest that these refinements would be unlikely to have a major impact on the conclusions drawn from this study.

The area where the greatest research effort is needed is in the evaluation of the intangibles or externalities associated with the forests. Until satisfactory values have been derived for these intangibles, it is impossible to arrive at an optimal solution which takes into consideration all benefits and costs. While the plea for greater research in this area has been made many times before, it is believed that the usefulness of the models constructed for this investigation may act as a further stimulus in this direction.

Finally, although the investigation is far from complete, it was possible to examine some of the more important issues by extrapolating from the results produced in this study. This is an important factor to bear in mind and consequently enhances the value of such studies.

A1.

APPENDIX 3.1

Paper 15

THE SOCIAL DISCOUNT RATE AND OPPORTUNITY COST OF CAPITAL IN FORESTRY DEVELOPMENT PROJECTS

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Introduction

The long-standing controversy over the social rate of discount (Pigou, 1932, Scott, 1955) has important implications for economic analyses of public investment in wood production. Price (1973), for example, stressed the impact of a discount rate of 10% in rendering upland afforestation unattractive relative to agriculture in recent cost-benefit analyses by the United Kingdom Treasury. But the impact of the discount rate is not confined to comparisons between forestry and other land uses. It pervades all economic analyses of forest practices and planning which involve choices between alternative temporal strategies, whether just a simple choice of the optimum rotation length, or a constrained optimization problem typical of modern planning techniques.

A recent survey by Schleicher (1972) showed that discount rates ranging from 6·5 to 10% were being used by various European countries in cost-benefit analyses of public investment. Baumol (1968) cited one example of a zero rate of discount; and others ranging from 3 to 9% used in the United States. This wide range of values probably only testifies to the predominance of projects with short investment horizons in the public sector, since choice between such projects is relatively insensitive to the choice of discount rate. However such a range of values is often extremely important to forestry projects, which typically involve long investment horizons.

This paper forms part of a larger study of the lower South Coast Region of New South Wales in which the choice of discount rate is likely to be critical. The aim of the larger study is to determine whether and to what extent society should invest in the conversion of marginal farmland to wood production by the establishment of plantations of radiata pine (*Pinus radiata* D. Don). The optimum set of strategies for regional wood production, both for the marginal farmlands and for the extensive areas of predominantly public forest in the region, is to be determined using a large linear programming model. The objective function of the linear programming model involves estimation of the present value[1] of the net social benefit per hectare for each strategy. While the constraints in the model are only specified

[1] Internal rates of return could be used instead but seem less robust (Henderson, 1965) and involve difficulties for much of the public forest. Market prices for this land are generally not available and opportunity costs must be imputed using the Faustmann approach. Calculation of the true internal rate of return would therefore involve prior calculation of the present value (see Bentley and Teeguarden, 1965).

over a 50 years planning horizon, the present values for each strategy are based on an infinite horizon (see Ferguson, 1974). The rate of discount will obviously play a critical role in determining the relative values for various strategies over such a long horizon.

The aim of this paper is therefore to examine the rate of discount and related parameters appropriate to this setting. While the values derived are to some extent specific to the setting, the issues and problems of estimation arise in many forestry projects in developing countries (e.g. Ferguson, 1973).

THE SOCIAL RATE OF DISCOUNT

The various approaches advocated for the social rate of discount can be classified into three broad groups based on the use of

(1) a market rate of interest, or

(2) a synthetic rate of interest, or

(3) a separate time preference rate and shadow price for capital.

Before considering each of these groups the treatment of inflation and of uncertainty needs to be considered.

Except where otherwise indicated, all interest rates, and all costs and prices, are assumed to be measured in "real" magnitudes relative to the purchasing power of money at some specified date. Whilst this assumption is not essential to the arguments which follow, it obviates the necessity of trying to estimate future rates of inflation, an especially difficult task at present.

Uncertainty plays an important role in the arguments relating to the social rate of discount and cannot be dismissed so readily. Nevertheless, it greatly simplifies the exposition to assume a world of certainty in the initial review, even though the effect of uncertainty is not entirely independent of some of the issues raised.

Market Rate of Interest

Hirshleifer, *et al* (1960), Nichols (1969), Mishan (1967a and b), and others argue that the social rate of discount, d, should be set equal to the market rate of interest (more specifically, to the marginal rate of return before tax on private investment), r_p. In a perfectly competitive economy, free from externalities, such a solution would be Pareto optimal because it would ensure that the marginal rates of substitution and of transformation between goods over time were everywhere equal. The total amount of investment would thus be optimal as would its allocation between private and public sectors.

The source of funds for public investment matters not in this approach (Musgrave, 1969). If the funds were withdrawn from private investment, the alternative perpetual return foregone at the margin would be r_p dollar for each dollar of investment. The present value of this consumption stream forgone is thus one dollar per dollar of investment, discounting at t_p. Since present consumption is the numeraire in most cost-benefit analyses, the opportunity cost of a dollar withdrawn from present consumption is also one dollar.

The main objection to this approach is that it assumes perfect competition exists in the capital market and in related markets: yet imperfections are obvious and abound. The multiplicity of interest rates, differences between borrowing and lending rates and use of various rationing devices in the private capital market are glaring examples of imperfections, as is the pervasive influence of government through the financial institutions and through taxes and borrowing generally.

A further objection relates to the probable existence of interdependence between the utility functions of individuals over time (Marglin, 1963, Sen, 1976). An individual may be willing to save more than his personal time preference would suggest, in the interests of increasing the consumption of future generations, provided others are willing to do likewise. Thus a divergence between private and social rates of time preference may arise, the latter being lower. The likely magnitude of this divergence is difficult to assess but seems unlikely to be great (Arrow, 1966).

In our opinion these objections[2] carry considerable weight. However, even if one rejects them in large measure, there seems to be an insurmountable practical objection to this approach. The changes needed to implement it are most unlikely to be instituted in the foreseeable future (Baumol, 1968).

To attain the Pareto optimal solution, private investment would have to be increased to drive the marginal rate of return on private investments down. This could be achieved making it easier for the private sector to borrow funds, either by reducing the borrowing rate (through an appropriate mixture of budgetary surplus and debt retirement) or by subsidy. In either event the corporate income tax would also have to be abolished. Such changes imply

[2] Dasgupta, *et al* (1972) stress a further argument that the intertemporal behaviour of individuals is not and cannot be rational and hence that the observed rates of time preference in the market have no normative significance. However, this comes dangerously close to throwing out the baby with the bathwater because the theory of welfare economics assumes rationality in behaviour. Moreover, since the empirical evidence on the rationality or otherwise of behaviour with respect to saving is the subject of debate, it would seem wiser not to stress this point.

a large increase in the direct or indirect financing of private investment by government, which is unlikely (Arrow and Kurz 1970). This leads us to seek a second-best solution.

Synthetic Rate of Interest

Baumol (1968), Drèze (1974), Harberger (1969), Ramsay (1969) and Usher (1969) have advocated second-best solutions in which the social rate of discount lies between the marginal rate of return on private investment and the social rate of time preference, i_g, i.e. $r_p > d > i_g$.

This solution arises because of the constraint which prevents government from ensuring that *private* investment is increased to the Pareto optimal level. Hence the social rate of time preference is likely to lie below the marginal rate of time preference in the private capital market. Under these circumstances, should not the social rate of discount reflect the differing opportunity costs of funds drawn partly from consumption and partly from private investment?

For example, at the margin a dollar of public investment drawn from consumption must earn a perpetual annual return of at least i_g in the future, otherwise it is better consumed now. Similarly a dollar withdrawn from private investment must yield a perpetual annual return of at least r_p otherwise it is better left for private investment. If the proportion of funds drawn from private investment is m, then the social rate of discount should be set at:

$$d = mr_p + (l-m)i_g \quad (1)$$

This is an excessively simple treatment of the approach: far more elaborate formal models have been developed.

Some of these models have yielded vastly different solutions for the appropriate value of the social rate of discount. The models of Arrow (1966), Kay (1972) and the earlier models of Arrow and Kurz (1970) assumed that consumption was unresponsive to the rate of interest, simply being proportional to disposable income. This extreme assumption of an imperfect capital market leads to a second-best solution where the social rate of discount is equal to the social rate of time preference. On the other hand, the models of Sandmo and Drèze (1971), Drèze (1974) and some other models of Arrow and Kurz (1970) assumed perfect capital markets where consumption was responsive to the rate of interest. These yielded a solution similar to equation (1). The model developed by Diamond and Mirrlees (1971) assumed perfect markets *and* the effective removal of the constraint on increasing private investment. It yielded a solution in which the social rate of discount equals the marginal rate of return on private investment.

This spectrum of results reflects the present difficulties of trying to develop an all-encompassing macro-level model yielding useful results for cost-benefit analysis at the micro-level. At the latter level "public investment" is not a homogeneous entity: the collective consumption characteristics, the sources of funding and the manner of charging for the goods and services vary from area to area within the public sector and often from project to project. It therefore seems more appropriate to examine what instrument or instruments are needed by the analyst dealing with a specific increment of public investment in order to achieve, or at least approach, the desirable targets for investment in the public sector.

There are two obvious targets to be considered (Baumol, 1968, Morawetz, 1972); the optimal allocation of resources over time and the efficient allocation of resources between the public and private sectors. At least two instruments are required to enable the analyst to approach these targets (Morawetz, 1972). Thus the social rate of time preference is one instrument whose use as a discount rate enables an optimal allocation of resources over time to be approached, while the efficient allocation of resources between the public and private sectors can be approached by using the opportunity cost of funds diverted from private investment as a second instrument.

Amalgamation of these two instruments as a synthetic rate of interest must distort the intertemporal allocation of resources, since the selection of projects will be biased towards those whose benefits arise earlier (*cet. par.*) by the use of a higher discount rate. Moreover the use of a single synthetic rate of interest assumes that all benefits and all costs of a particular investment have the same opportunity costs, which is rarely true. There may be differences between the sources of some of the funds used in particular projects such that there are marked differences in the opportunity costs between different projects. Similar considerations hold for benefits, especially since in some cases these are unpriced and accrue directly to consumers, whereas others are priced and thus accrue to the government for reallocation to investment or consumption. Feldstein (1972) provides some simple illustrations of projects where the use of a synthetic rate of interest would yield ridiculous results under various conditions.

Time Preference Rate and Shadow Prices

Separate recognition of the social rate of time preference as the discount rate and shadow prices for the opportunity costs seems essential. More than one shadow price is required because different sources (or sinks) of funds have different characteristics with respect to their opportunity costs. As with the approach in the previous section, this is a second-best solution. While the use of these instruments may provide the best attainable allocation of resources between projects and over time in the public sector, it does nothing to change the level of private investment and is therefore unlikely to be Pareto optimal.

This approach stems from the earlier work of Steiner (1959), Marglin (1963), Feldstein (1964) and others. The derivation of a shadow price may be illustrated by extension of the argument used to derive equation (1) in the previous section. If, in our over-simplified setting, the perpetual annual returns forgone by undertaking public investment were as shown in equation (1), then the shadow price for the funds used, P, can be calculated by capitalizing that annual return at the appropriate discount rate, i_g:

$$P = (mr_p + (1-m)i_g)/i_g$$
$$= m(r_p/i_g) + (1-m) \quad (2)$$

This formulation was first derived by Marglin (1963). However it assumes a fixed division of funds into two categories, private investment and consumption. In this study three basic sources of, or sinks for, funds will be recognized. They are (1) consumption, (2) public investment and (3) private investment, after Dasgupta *et al* (1972). Basic shadow prices can be formulated for each of these categories and these will be further refined in a subsequent section to relate the shadow prices to functional costing categories.

The shadow price for funds drawn from (or going to) consumption, P_c, is equal to one, since consumption is the numeraire and no distinction is made made between public and private consumption.

At the margin the shadow price for funds drawn from (or going to) public investment will equal the capitalized value of the perpetual annual returns otherwise accruing from direct contributions to consumption and to investment. If the marginal propensity to save in the public sector is m_g, the direct contribution to consumption must equal $(1-m_g)r_g$, where r_g denotes the marginal rate of return on public investment. The direct contribution to investment is obviously $m_g r_g$. But each such dollar must be valued at its own opportunity cost or shadow price P_g. Hence the shadow price for public investment funds is given by

$$P_g = [(1-m_g)r_g + P_g m_g r_g]/i_g$$
$$\text{Or } P_g = (1-m_g)r_g/(i_g-m_g r_g) \quad (3)$$

At the margin funds drawn from (or going to) private investment can be similarly treated. However there is a further initial stage involved here because of the existence of taxes. If the marginal tax rate is denoted by t, then the direct contributions is equal to $[(1-m_g)r_p + P_g m_g r_p]t$. The direct contribution to consumption and private investment from private income is $[(1-m_p)r_p + P_p m_p r_p]$ (1-t), where m_p denotes the marginal propensity to save out of private income and P_p denotes the shadow price of private investment funds. Thus the complete formula for the shadow price of private investment funds is:

$$P_p = \frac{[(1-m_g)r_p+P_g m_g r_p]t+[(1-m_p)r_p+P_p m_p r_p](1-t)}{i_g} \quad (4)$$

This expression can be simplified by substituting equation (3) in it and transposing terms. However, because of assumptions made later regarding the empirical values of some of these variables, it is simpler to leave it in this form. This formulation follows that of Dasgupta, *et al*, (1972).

There are important assumptions involved in this approach (Dasgupta, *et al*, 1972). For example, in equations (3) and (4) it is assumed that the benefits from public investment at the margin are recaptured by the government as revenues. If this is not true, these equations may tend to overestimate the shadow prices somewhat. In fact this problem does not arise in the later refinements of these equations in this study, because of some further assumptions.

It is also apparent that this formulation assumed a stationary state in which the values of marginal propensities to save and rates of return remain constant over time. This seems appropriate for the larger study to which this paper is directed, since similar assumptions are involved there also. Moreover Dasgupta *et al* (1972) have shown that these formulae provide good approximations of the shadow prices over time provided r_p and i_g remain markedly different for a substantial period of time. However, this assumption may not be valid or safe for developing countries, where the difference between r_p and i_g may narrow substantially over the next two or three decades (Newberry, 1972, Ferguson, 1973).

Finally, this approach eschews consideration of distributional aspects of the costs and benefits of public investment (Azzi and Cox, 1974). This also seems justified in relation to the setting of the larger study to which this paper is directed. Consideration of the distributional aspects of this study can probably be safely left to a simple tabular analysis of the final results of the model (Ferguson, 1974). However such aspects may require explicit consideration for some projects in developing countries, either by way of the introduction of weights for merit wants (Dasgupta, *et al*, 1972) or application of the approach suggested by Azzi and Cox (1974).

RISK AND UNCERTAINTY

Since the traditional distinction between risk and uncertainty has little bearing on the issues raised in this paper, the two terms will be regarded as synonyms.

Relaxation of the earlier assumption of complete certainty raises complex issues. Most individuals are believed to be averse to risk. Should the criteria used in analyzing public investment be adjusted to reflect this aversion to risk? If so, how should the adjustment be made?

Hirshleifer and Shapiro (1970) argued that the criteria should reflect risk aversion and that the adjustment is best achieved by including an appropriate margin for risk in the social rate of discount. They held that there is a high correlation between private and social risk. Hence the rate of interest established for private investments of a comparable risk class can be used in analyzing public investments, since this rate incorporates an appropriate margin for risk.

Arrow and Lind (1970), however, have shown that the costs of risk-bearing become negligible in public investment provided benefits and costs are uniformly spread over a large population and are independent of social income. Under these circumstances a risk-neutral approach is appropriate for the analysis of public investment. Moreover, Arrow and Lind (1970) pointed out that the private markets for contingent claims (e.g. insurance) are markedly imperfect because of the existence of moral hazard and the high costs of transactions. The risk margins established in private markets therefore have little relevance for public investment (see also Zeckhauser 1970). In contrast to Hirshleifer and Shapiro (1970), they assumed complete independence between private and social risk. The larger study of regional wood production to which this paper is addressed seems to meet the conditions described by Arrow and Lind (1970) and a risk-neutral approach therefore seems appropriate. However there may well be other forestry projects where the costs of risk bearing are not negligible. Projects involving massive investment which are likely to have a substantial impact on national income are obvious examples. Some degree of risk-aversion would seem desirable under these circumstances, although how much is not clear.

Finally, this brief review has skirted the largely unresolved problem relating to uncertain consumer preferences. Recent work by Schmalensee (1972) suggested that risk-neutrality may still be justified but these results were not conclusive. This problem may be important where benefits are unpriced and an option demand is involved.

SOCIAL RATE OF TIME PREFERENCE

The range within which the social rate of time preference is likely to lie can be identified by reference to a formula derived from a simple theory of economic growth (Dasgupta *et al* 1972):

$$i_g = \lambda\theta \tag{5}$$

where i_g denotes the social rate of time preference,
λ denotes the absolute value of the elasticity of marginal utility with respect to per capita consumption
θ denotes the rate of growth of per capita consumption.

The rate of growth of per capita consumption in Australia was 2·5% per annum over the period 1959 to 1972. The elasticity of marginal utility with respect to per capita consumption seems to lie in the range 1 to 2·5 (Layard, 1972). Thus the social rate of time preference probably lies in the range 2·5 to 6·25%. This is still far too wide a range to provide a useful basis for analysis. Inevitably we are driven to look at existing rates of interest for guidance in attempting to narrow the range.

Interest rates in the private sector in Australia are patently unusable because they reflect risk and the other market imperfections. The rates in the public sector are relatively free of risk but are effectively controlled (Mathews, 1967) by the central bank. Moreover most financial institutions are *forced* investors in this market so the central bank has the ability to set or influence rates to levels which may differ markedly from considerations of time preference or rates of return.

There is, however, one class of security transaction which provides some guidance. The rate of interest payable on Australian securities sold in overseas markets is at least indicative of what the government, or more accurately the central bank, is willing to pay. Presumably then it should reflect the marginal rate of return on public investment. If the level of public investment is optimal, or nearly so, it will also be indicative of the social rate of time preference. Admittedly these assumptions are tenuous, but they are more credible than using any of the rates in the Australian market. The rate of interest on these loans is also relatively free of risk and is established in markets in which the Australian government has no direct leverage.

Using loans raised in the New York and London markets as a basis, the yield rates for the period 1966 to 1972 varied from 6·1 to 8·2% in New York and from 7·1 to 10·8% in London, according to the official statistics of the Reserve Bank of Australia. The average rates over this period were 7·2 and 8·7% for New York and London respectively. Modigliani and Shiller (1973), in a study of the long term rates in the securities market in the United States, have shown that the long term rates seem to be determined by the average expected short-term rate and the *historical* average level of inflation. The yield rates for 1966 to 1973 were therefore deflated using the average rate of inflation from 1950 to the year in question. The "real" rates so calculated ranged from 4·3% to 5·9% for the New York market, and from 3·3% to 6·2% in the London market; the average rates being 5·1 and 4·7% respectively.

This exercise has narrowed the range down but still leaves the actual value to be chosen. The cost of computation in the linear programming model precludes complete recalculation for a range of rates, although sensitivity tests can be made. Moreover, we are suspicious of analyses which reproduce copious values for different discount rates leaving the final selection of the discount rate and optimal strategy to the central planner or other decision-maker (cf. Dasgupta, *et al*, 1972). This practice seems to shift the burden of responsibility to a point which invites personal bias and inconsistency in project selection, since decision-makers at this level are unlikely to have the time or interest to study the matter in depth. Decisions on the rate of discount need to be taken before the cost-benefit analysis is made (Mishan 1974) and the basis for these decisions made clear. The ultimate decision-maker can then weigh the results, the assumptions, and the sensitivity tests in a better-informed and, hopefully, more objective manner.

A value of 5% has been selected for use as the social rate of time preference in this study, corresponding roughly to the median value of the data prescribed earlier. No great precision can be imputed to this figure but it does seem likely that the true value lies between 4 and 6%.

SHADOW PRICES

The shadow prices outlined earlier require refinement to relate them directly to the accounting and budgeting categories used in Australian public enterprises. The following categories are generally used in public accounting and budgeting (Mathews, 1967):

(i) Consolidated revenue funds

(ii) Trust funds

(iii) Loan funds.

These categories admittedly reflect historical accounting and budgeting methods rather than meaningful economic identities. However they do form the basis for costing, budgeting, and resource allocation within the public service. So long as this is the case it seems appropriate to apply different shadow prices to them.

Consolidated Revenue Funds

These funds are raised from taxes and from revenues of public enterprises. Taxes fall largely on consumption, the main exceptions being the corporate income taxes and personal income taxes on the higher levels. Some arbitrary allowance for these exceptions has been made in dealing with loan funds. Thus for present purposes it may be assumed that the tax component of consolidated revenue funds is derived entirely from consumption and therefore has a shadow price of one.

Public enterprise revenues, however, may be identified with either consumption or with public investment since they may offset increases in taxes to some extent, but they may also represent a source of finance for public investment.

The marginal rate of return on public investment (r_g) has already been assumed to be equal to the social rate of time preference (i_g). Equation (3) therefore collapses so that the shadow price for public investment is also one. This somewhat fortuitous result means that a uniform shadow price of one applies to all costs in this category.

Trust Funds

These are generally derived from the revenues of the public enterprise concerned and are funds allocated to some specific use, generally under the control of the public enterprise concerned. Under Section 13 of the Forestry Act of New South Wales, 1961, for example, one-half of the gross receipts of the Forestry Commission is set aside in a Special Deposit Account for use in afforestation and other specified purposes under the control of the Forestry Commission. These funds are clearly related to public investment and hence have a shadow price of one.

Loan Funds

Loan Funds are raised either from the sale of government securities, mainly within Australia, or from the surplus on the current account of the Australian government (Mathews, 1967). The main purchasers of government securities are the financial and quasi-financial institutions, such as the banks, life assurance firms, and the like. The nature of their business is such that these funds would almost certainly flow to private investment but for the legal requirements that they invest a substantial portion of their funds in this manner.

It is difficult to identify funds from the Australian Government surplus on current account with a particular source, in terms of investment or consumption. Since loan funds are the main source of finance for new projects in the public sector, it seems appropriate to adopt a somewhat conservative approach to ensure their efficient use. Thus loan funds from this surplus have also been assumed to have been diverted from private investment, by way of corporate income taxes or personal income taxes on higher incomes.

Equation (4) is thus appropriate for the estimation of the opportunity costs of the *initial* transfer of loan funds to the public sector. However Feldstein (1972) pointed out that this treatment is incomplete in the case of debt because debt carries an obligation of repayment. The impact of these repayments should also be taken into account.

In Australia, interest payments on government securities are financed out of taxes but are refinanced at maturity by further debt issue. Under these circumstances Feldstein (1972) has shown that adjustments to the shadow price in equation (4) are necessary to reflect both the costs of the additional taxes required to finance interest payments, and the offsetting benefits stemming from the further use of these interest payments by the debt-holders.

The critical issue in this adjustment is whether the marginal propensity to save of the debt-holders is different to that of the marginal propensity to save of the private sector in general. While no data or evidence are available, it seems unlikely that any difference exists in Australia. If the two are equal, the adjustments will exactly offset one another and hence no adjustment has been made to equation (4) in this study.

Equation (4) involves the shadow price for funds diverted from public investment which, under the assumption outlined earlier, equals one. Equation (4) therefore simplifies to the following expression:

$$L = \frac{r_p\,[1 - m_p\,(1 - t)]}{i_g - r_p m_p\,(1 - t)} \qquad (6)$$

where L denotes the shadow price of loan funds.

The marginal tax rate on corporate income is ·475, this being the nominal rate of tax on corporate income. The composite marginal tax rate on personal income is not known but is likely to be similar to this value.

The marginal propensity to save was estimated by Haig (1971) to be ·19, based on an analysis of national income statistics. This figure includes public sector saving which would be higher than the private sector. The marginal propensity to save in the private sector has therefore been set at ·15.

While some data are available on the average real rates of return (Fairbairn and McShane 1969) they are of little value in gauging the marginal rate of return before tax in private investment. We have selected a figure of ·12 because it seems to reflect the guiding rate used in business once allowance is made for risk and inflation.

Substituting these values in equation (6) the shadow price for funds in this category is equal to 2·73. Thus each dollar of loan funds used will be priced at $2·73 in calculating net social benefit.

Since the choice of the values used is open to debate some examination of the sensitivity of the shadow price to changes in them is desirable. The values of shadow price corresponding to various values of the variables in equation (5) are shown in Table 37.

TABLE 37

ESTIMATED VALUES OF THE SHADOW PRICE FOR LOAN FUNDS

Marginal rate of return r_p%	Marginal propensity to save m_p%	Social rate of time preference i_g 4%	5%	6%
11	15	3·23	2·45	1·97
	16	3·28	2·47	1·98
12	15	3·62	2·73	2·19
	16	3·67	2·75	2·20
13	15	4·02	3·01	2·41
	16	4·09	3·05	2·43

The shadow price is relatively insensitive to changes in the value of the marginal propensity to save in the private sector, at least in the range which seems sensible, from the evidence available. As might be expected, the shadow price is more sensitive to changes in the marginal rate of return before tax on private investment, but not unduly so.

Changes in the social rate of time preference produce the largest changes in the shadow price. However these changes are mutually offsetting to some degree in their impact on net social benefit.

Revenues

A portion of the revenues of most, if not all, state forest services are returned by law to trust funds. Clearly these relate to public investment and have a shadow price of one. The remaining revenues go into the consolidated revenue fund and hence also have a shadow price of one, under the assumptions made earlier.

CONCLUSIONS

A Pareto optimal solution, letting both public and private sectors adjust to a common rate of interest, seems infeasible because of the existence of various market imperfections. Acceptance of a continuing difference between the social rate of time preference and the marginal rate of return on private investment involves acceptance of a second-best solution.

The suggested use of a synthetic discount rate to take account of the opportunity cost of funds diverted from private investment distorts the temporal allocation of the goods provided by the public sector. Project selection is similarly biased towards short-lived projects or those whose main benefits accrue earlier in the life of the project.

Use of the social rate of time preference as a discount rate and of a separate shadow price (or prices) for scarce capital avoids these problems. At the same time, the principle of valuing scarce resources in terms of their opportunity cost is maintained. The distinction between this approach and that based on the use of a synthetic discount rate is likely to be especially significant in social cost-benefit analyses of long-lived projects, such as those involving investment in wood production.

Estimates of the social rate of time preference and of the shadow prices of the various sources of public investment funds have been made. The shadow prices have been further refined to enable them to be applied to the categories used for costing and budgeting public investment in Australia. While these estimates provide a starting point for social cost-benefit analyses, their shortcomings must also be acknowledged. Deficiencies in the data available necessitated sweeping assumptions at a number of important points. Further research is needed to clarify these points and to improve the basis of the estimates.

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REFERENCES

ARROW, K. J., (1966). Discounting and public investment criteria, pp. 13–32 in A. V. Kneese and S. C. Smith, (Eds.) *Water Research*, John Hopkins, Baltimore.

ARROW, K. J. and KURZ, M., (1970). *Public Investment, the Rate of Return, and Optimum Fiscal Policy*. Published for Resources for the Future, John Hopkins, Baltimore.

ARROW, K. J. and LIND, R. C., (1970). Uncertainty and the evaluation of public investment decisions. *Amer. Econ. Rev.* 60 (3): 364–378.

AZZI, C. F., and COX, J. C., (1974). Shadow prices in public program evaluation models. *Quar. J. Econ.* 88 (1): 158–165.

BAUMOL, W. J., (1968). On the social rate of discount. *Amer. Econ. Rev.* 58 (4): 788–802.

BENTLEY, W. R. and TEEGUARDEN, D. E., (1965). Financial maturity, a theoretical review. *For. Sci.* 11 (1): 76–87.

DASGUPTA, P., SEN, A. K. and MARGLIN, S. A., (1972). *Guidelines for Project Evaluation*. UNIDO Project Formulation and Evaluation Series 2, United Nations, New York, 383 pp.

DIAMOND, P. A., and MIRRLEES, J. A., (1971). Optimal taxation and public production. *Amer. Econ. Rev.* 61 (1): 8–27 and (3): 261–278.

DRÈZE, J. H., (1974). Discount rates and public investment: a post-scriptum. *Economica* 41 (161): 52–61.

FAIRBAIRN, I. J. and MCSHANE, R. W., (1969). The return on equities and fixed interest securities on the Australian capital market. *Econ. Rec.* 45 (1): 116–123.

FELDSTEIN, M. S., (1964). The social time preference discount rate in cost-benefit analysis. *Econ. J.* 74 (294): 360–379.

FELDSTEIN, M. S., (1972). The inadequacy of weighted average discount rates, pp. 311–332 in R. Layard (Ed.) *Cost-Benefit Analysis*, Penguin, Harmondsworth.

FERGUSON, I. S., (1973). The Economics of Plantation Forestry in the Savanna Region of Nigeria. *Savanna Forestry Research Station Working Document* FO:DP/NIR/64/516, FAO, Rome, 99 pp.

FERGUSON, I. S., (1974). Land-use planning: analysis and action. *Aust. For.* 37 (1): 3–14.

HAIG, B. D., (1971). *The Australian Economy to the Year* 2000. Unpublished report for the Australian Road Research Board, The author, Canberra, 238 pp.

HARBERGER, A. C., (1969). Professor Arrow on the social discount rate, pp. 81–8 in G. C. Somers and W. D. Wood (Eds.), *Cost-Benefit Analysis of Manpower Policies*, Proc. of a North Amer. Conf., Indust. Relations Centre, Queens Univ., Kingston.

HENDERSON, P. D., (1965). Notes on public investment criteria in the United Kingdom, pp. 86–167 in R. Turvey (Ed.), *Public Enterprise:* Selected Readings, Penguin, Harmondsworth.

HIRSHLEIFER, J., DE HAVEN, J. C. and MILLIMAN, J. J., (1960). *Water Supply: Economics, Technology and Policy*. Univ. of Chicago, Chicago, 386 pp.

HIRSHLEIFER, J. and SHAPIRO, D. L., (1970). The treatment of risk and uncertainty, pp. 291–313 in R. H. Haveman and J. Margolis (Eds.), *Public Expenditures and Policy Analysis*, Markham, Chicago.

KAY, J. A., (1972). Social discount rates. *J. Public Econ.* 1:359–378.

LAYARD, R., (1972). Introduction, pp. 9–65 in R. Layard (Ed.), *Cost-Benefit Analysis*. Penguin, Harmondsworth.

MARGLIN, S. A., (1963). The social rate of discount and the optimal rate of investment. *Quar. J. Econ.* 77 (1): 95–112.

MATHEWS, R., (1967). *Public Investment in Australia.* Cheshire, Melbourne, 461 pp.

MISHAN, E. J., (1967a). A proposed normalization procedure for public investment criteria. *Econ. J.* 77 (308): 777–796.

MISHAN, E. J., (1967b). Criteria for public investment: some simplifying suggestions. *J. Pol. Econ.* 75 (2): 139–146.

MISHAN, E. J., (1974). Flexibility and consistency in project evaluation. *Economica* 41 (161): 81–96.

MODIGLIANI, F. and SHILLER, R. J., (1973). Inflation, rational expectations, and the term structure of interest rates. *Economica* 40 (157): 12–43.

MORAWETZ, D., (1972). The social rate of discount, targets and instruments. *Public Fin.* 27 (3): 370–374.

MUSGRAVE, R. A., (1969). Cost-benefit analysis and the theory of public finance. *J. Econ. Lit.* 7 (3): 797–806.

NEWBERRY, D., (1972). Public policy in the dual economy. *Econ. J.* 82 (326): 567–90.

NICHOLS, A., (1969). On the social rate of discount: comment. *Amer. Econ. Rev.* 59 (5): 909–911.

PIGOU, A. C., (1932). *The Economics of Welfare.* Macmillan, London, 876 pp.

PRICE, C. H., (1973). To the future: with indifference or concern? The social discount rate and its implications in land use. *J. Agric. Econ.* 24: 393–397.

RAMSAY, D. D., (1969). On the social rate of discount: comment. *Amer. Econ. Rev.* 59 (5): 919–924.

SANDMO, A. and DRÈZE, J. H., (1971). Discount rates for public investment in closed and open economics. *Economica* 38 (152): 395–412.

SCHLEICHER, H., (1972). On European Social Rates of Discount: Survey, *Finanzarchiv* 31 (3): 434–440.

SCHMALENSEE, R., (1972). Option demand and consumer's surplus: valuing price changes under uncertainty. *Amer. Econ. Rev.* 62 (5): 813–824.

SCOTT, A., (1955). *Natural Resources: The Economics of Conservation.* Univ. of Toronto Press, Toronto, 184 pp.

SEN, A. K., (1967). Isolation, assurance and the social rate of discount. *Quar. J. Econ.* 81 (1): 112–124.

STEINER, P. O., (1959). Choosing among alternative public investments in the water resource field. *Amer. Econ. Rev.* 49 (5): 893–916.

USHER, D., (1969). On the social rate of discount: comment. *Amer. Econ. Rev.* 59 (5): 925–929.

ZECKHAUSER, R., (1970). Uncertainty and the need for collective action, pp. 96–116 in R. H. Haveman and J. Margolis (Eds.), *Public Expenditures and Policy Analysis*, Markham, Chicago.

DISCUSSION OF PAPERS BY MESSRS STRAIN, PHILIP, FERGUSON AND REILLY

CHAIRMAN: PROFESSOR F. JØRGENSEN

MR. STRAIN argued that systems analysis, or, more precisely, systems dynamics, which was geared towards the establishment of a logical structure of relationships between variables, called for much less detailed data than other operational research techniques or cost-benefit analysis. Apart from its value to analysts and planners, systems dynamics had an educational role for politicians in clarifying the effects of various options. The group concentrated attention on the point about the amount of information needed to make a systems model operational. In contrast to cost-benefit analysis, which required one to decide which effects were 'costs' and which 'benefits', systems analysis simply provides data about how variables develop as a consequence of particular actions. It was concluded that systems dynamics had a role which was complementary to that of cost-benefit analysis: it was not a substitute.

Although MR. PHILIP's paper dealt solely with the recent history of the U.K. private forestry sector, a most important conclusion could be drawn from his review. This was that it appeared dangerous and wasteful of resources to create unnecessary confusion by carrying through drastic changes in policy. Nowhere was this more true than in long-term business where the maintenance of confidence was especially important.

DR. FERGUSON'S AND MR. REILLY'S valuable survey of theories on the selection of an appropriate discount rate for use in investment analysis of projects in the public sector concluded that the use of the social rate of time preference (STP) combined with a shadow price for capital was most likely to give the optimal allocation of resources. Discussion concentrated on the question of the relative magnitudes of the marginal rate of return and the STP rate and the desirability of showing the implications of choices of alternative possible rates and shadow prices in actual investment appraisals.

APPENDIX 4.1

DETAILED YIELD TABLES FOR RADIATA PINE PLANTATION

STRATEGIES A, B AND C

Age	Before thinning			Thinning			Yield (m^3/ha)		
	DBH (cm)	BA (m^2/ha)	Trees/ ha	DBH (cm)	BA (m^2/ha)	Trees/ ha	Pulp	Saw- log	Total
FORESTRY A - Site Index 24									
15	15.9	34.7	1551		Clearfell		237	-	237
20	18.9	48.4	1551		"		396	-	396
25	20.6	59.6	1551		"		565	-	565
FORESTRY A - Site Index 27									
15	16.5	37.6	1576		Clearfell		284	-	284
20	19.3	52.2	1576		"		475	-	475
25	21.3	64.2	1576		"		672	-	672
FORESTRY B - Site Index 24									
15	15.9	34.5	1551	13.6	14.2	815	93	-	93
20	22.9	31.4	736	20.7	8.4	238	54	15	69
25	28.5	33.0	498	26.2	10.4	184	13	83	96
30	34.4	30.1	314		Clearfell		15	306	321
35	37.9	36.7	314		"		14	416	430
40	40.6	42.2	314		"		13	513	526
FORESTRY B - Site Index 27									
15	16.5	37.6	1579	13.9	13.9	759	93	-	97
20	23.1	35.8	820	21.2	12.7	340	81	31	112
25	29.3	33.3	480	27.1	10.4	175	13	95	108
30	35.3	30.7	305		Clearfell		15	346	361
35	39.0	37.6	305		"		14	474	488
40	41.9	43.5	305		"		13	591	604
FORESTRY C - Site Index 24									
20	28.2	40.8	633	25.8	17.8	328	19	119	138
25	36.6	32.4	304	34.5	9.3	98	3	81	84
30	43.1	30.4	206		Clearfell		5	315	320
35	47.4	36.8	206		"		4	420	424
40	50.8	42.2	206		"		4	517	521
FORESTRY C - Site Index 27									
20	29.3	43.0	618	20.1	27.3	328	20	156	176
25	37.8	32.9	290	36.0	9.9	96	-	99	99
30	44.8	30.8	194		Clearfell		-	366	366
35	49.6	37.8	194		"		-	500	500
40	53.3	43.7	194		"		-	622	622

APPENDIX 4.2

BASIS OF FIELD COSTS ADOPTED FOR RADIATA PINE PLANTATION STRATEGIES

SILVICULTURAL OPERATIONS

Silvicultural assumptions were as follows:-

(i) Planting site was cleared of all timber which is pushed into windrows to be burnt before planting.

(ii) Initial spacing was 3 m x 2.2 m (1550 t/ha).

(iii) Refilling was carried out in the same year as planting.

(iv) Pre-commercial thinning. This applied to Forestry C only and involved the thinning to waste of 900 to 950 t/ha at age 6-7 years.

(v) Pruning

- Forestry B Ground Pruning. All trees were pruned to a height of approximately 2.4 m at age 7 to 8 years.

Forestry C - First pruning. The trees retained at pre-commercial thinning were pruned to 2.4 m at 7 to 8 years old.

- Second pruning. 300 trees/ha were selected for pruning to 4.3 m.

- Third and final pruning. The 300 trees/ha selected for second pruning were carried up a further lift to 6 m.

TABLE 4.2.1

Summary of field costs, machine usage and labour requirements for silvicultural operations in Forestry A, B and C

Operations	Field cost ($)	Machine-hours per ha	Man-hours per ha
Clearing:			
Contract	100.0	N.A.	N.A.
Forestry Commission	70.0	5.2	6.0
Cultivation:			
Ploughing	27.0	1.4	2.1
Ripping:			
Less than 18°	17.0	1.2	1.5
More than 18°	27.0	1.5	2.1
Planting:			
Manual	30.0	-	13.0
Machine	27.0	1.3	5.0
Pruning - Forestry B			
Ground prune to 2.4 m	65.0	-	28.4
Pruning - Forestry C			
0 to 2.4 m	42.0		18.2
2.4 to 4.3 m	23.0		10.0
4.3 to 6.0 m	29.0		12.5
Pre-commercial thinning	55.0		23.1

Estimated field costs, direct machine-hours and labour requirements for the above silvicultural operations are summarized in Table 4.2.1. The bases for these estimates are as follows:-

(a) Clearing. A cost of $100/ha was adopted on the assumption that complete clearing including stump removal would be carried out as a necessary prerequisite for intensive cultivation. Only 5 percent of the land in each management area was assumed to require clearing; thus an allocated cost of $5/ha was adopted for costing purposes.

(b) Cultivation. Since most of the farmlands has been cultivated at least once previously either for the establishment of improved pastures or for cropping, one double-disc ploughing was considered adequate. Thus a cost of $27/ha was assumed.

(c) Fertilizer. Although the farming areas were known to be deficient in phosphorus, top-dressing of pastures has been carried out in the region for at least the past 10 years. Therefore it was assumed some residual effect will remain in the soils, thus avoiding the necessity to top-dress with a heavy aerial spread of superphosphate at planting. However, an individual tree application was carried out using .125 tonne/ha of N + P fertilizer at a subsidized cost of $67/ha plus $10/ha for labour.

(d) Planting. Planting costs did not seem to differ greatly between manual or machine operations so that either method can be applied. Therefore total costs/ha incurred on planting were estimated to be:-

Planting (1550 trees/ha)	28.5
Seedlings (1550 @ .06 cent)	9.3
Cartage	2.2
Refilling (5% of area)	5.0
TOTAL	$45.0

(e) Pre-commercial thinning. The estimated cost of this operation was based on a rate of 1.73 man-days/ha (Fenton 1972) for pre-commercial thinning from 750 to 200 t/ha at a stand height of 10.7 m. This is equivalent to 1.5 man-minutes/tree which was used for costing purposes.

(f) Pruning - Forestry B. This was based on costs experienced by the New South Wales Forestry Commission which indicated that this operation would require just over 1 man-minute/tree. Using a rate of 1.1 man-minute/tree, the time of 28.4 man-hours/ha shown in Table 4.2.1 was estimated.

(g) Pruning - Forestry C.

(i) First pruning. The pruning time shown in Table 4.2.1 was based on Fenton's (1972) estimate of approximately 1.75 man-minutes/tree for pruning 625 to 750 t/ha to 2.3 m.

(ii) Second pruning. Reported pruning times varied considerably but a rate of 2.0 man-minutes/tree was considered to be reasonable based on the studies by Terlesk (1969), Brown (1970) and Rogers (1970).

(iii) Third and final pruning. The estimate of 2.0 man-minutes/tree for second pruning was increased subjectively to 2.5 man-minutes for the purposes of this calculation.

ROADING COST

Roading networks in Forestry Commission plantations typically average 8 km/1000 ha of primary access road and 24 km/1000 ha of secondary access roads. Although roads are usually constructed a year or so before planting, it was assumed in this study that these operations would be carried out in the same year as planting. Furthermore since most of the management areas in the farming country are already provided with adequate primary access and some secondary access, it was assumed that additional primary access roads would not be needed and that only about 14 km/1000 ha of secondary access roads would be constructed at a cost of $900/km.

BUILDINGS

Additional expenditure on building construction was assumed to be required for the coastal management areas since any new plantation project there would be administered either from Eden or Bega. Buildings required and their respective costs were estimated to be:-

2 fire towers 12 m at $500/metre	$ 12,000
1 Store/garage/office complex	50,000
1 nursery	5,000
1 nursery water supply	5,000
1 cottage at nursery	20,000
Other structures	8,000
Total	$100,000

Most of the labour employed from the region was assumed to have their own accommodation and would be compensated by means of allowances for travelling to and from the job.

SURVEYS

This mainly includes the original design and location surveys. It is simply an allocated estimate based on Forestry Commission costs but allowing for property boundary surveys and transaction costs incurred during transfer of the land to the Forestry Commission.

ANNUALLY RECURRING COSTS

Again as for surveys this is an allocated cost based on Forestry Commission estimates. They cover annual outlays on fire protection, control of disease, vermin and noxious weeds, and maintenance of roads, buildings and other structures.

APPENDIX 4.3

COSTS OF PRODUCTION FOR FORESTRY A AND B BY SOURCE OF FUNDS INCLUDING THEIR SOCIAL OPPORTUNITY COSTS AT SOCIAL RATES OF DISCOUNT OF 4, 5 AND 6 PERCENT ($/HA)

Year	Operation	Loan Fund 4%	Loan Fund 5%	Loan Fund 6%	Revenue Fund	Trust Fund
	First Rotation (R)					
0	Establishment	485.8	366.4	293.0	72.6	11.0
1	Weed and coppice control	21.7	16.3	13.1	3.0	-
7	Ground pruning (Forestry A only)	258.8	195.2	156.6	35.8	-
	Second and subsequent Rotations					
R	Re-establishment	132.0	132.0	132.0	66.0	-
R+1	Weed & Coppice control	6.0	6.0	6.0	3.0	
R+7	Ground pruning	71.5	71.5	71.5	35.8	
Annual recurring costs		-	-	-	3.5	7.0

APPENDIX 4.4

COSTS OF PRODUCTION FOR FORESTRY C BY SOURCE OF FUNDS INCLUDING THEIR SOCIAL OPPORTUNITY COSTS AT SOCIAL RATES OF DISCOUNT OF 4, 5 AND 6 PERCENT ($/HA)

Year	Operation	Loan Fund 4%	Loan Fund 5%	Loan Fund 6%	Revenue Fund	Trust Fund
	First Rotation (R)					
0	Establishment	485.8	366.4	293.9	72.6	11.0
1	Weed & Coppice control	21.7	16.3	13.1	3.0	-
7	Non-commercial thinning	219.0	165.2	132.5	30.3	-
	Ground pruning to 2.5 m	167.2	126.1	101.2	23.1	-
9-10	Prune to 4.3 m	91.6	69.1	55.4	12.7	-
13-14	Prune to 3 m	115.5	87.1	69.9	16.0	-
	Second & subsequent Rotation					
R	Re-establishment	132.0	132.0	132.0	66.0	-
R+1	Weed & Coppice control	6.0	6.0	6.0	3.0	-
R+7 9-10 13-14	Pruning & non-commercial thinning	106.7 25.4 32.0	106.7 25.4 32.0	106.7 25.4 32.0	53.4 12.7 16.0	
Annual recurring costs					3.5	7.0

APPENDIX 4.5

COMPOSITION OF COSTS OF 'OTHER MATERIALS' AND 'SERVICES AND CONTRACTORS' FOR DAIRYING A STRATEGY

Item	Cost ($)
Other Materials:-	
Electricity ($2.5/cow)	500
Fuel, oil and grase ($4.5/cow)	900
Repairs:	
Plant and equipment	600
Structures	300
Seed:	
Oats (129kg/ha @ $0.083 on 20 ha)	210
Pasture replacement ($26/ha on 28 ha/an)	730
Dairy requisites ($5/cow)	1,000
Miscellaneous($2.0/cow)	400
TOTAL	4,640
Services and Contractors:-	
Vetinary fees ($2/cow)	400
Rates and taxes ($2/ha)	600
Insurance	300
Miscellaneous	600
TOTAL	1,900

APPENDIX 4.6

BASIS FOR ESTIMATED COSTS OF PRODUCTION FOR BEEF GRAZING STRATEGIES

A. Labour Family and Hired

Since there was no available estimate from the Region, it was necessary to use data from the Australian Beef Cattle Industry Survey (ABCIS) 1968/69 to 1970/71 (McCumstie 1973). Since the owner-operator on the farms sampled by the Survey in the Coastal region of New South Wales did not average a full year's work on the farm, it was not possible to use the estimate for family and hired labour directly from the Survey. An approximation was estimated by the following method:-

(1)	Total cost of family, hired and owner-operator labour for the Coastal region ($1969/70)	$2,944
(2)	Deduct cost of owner-operator labour	$2,299
(3)	Approximate value of family and hired labour ($1969/70) = (1) - (2)	$ 645
(4)	Value/head of cattle equivalent = (3)/191	$ 3.38
(5)	(4) expressed in $1972/73 = 3.38 x 1.2530	$ 4.23
(6)	Cost of hired and family labour for each strategy may be calculated as follows:-	
	Beef Grazing A = 275 x $4.23	$1,163
	Beef Grazing B = 300 x $4.23	$1,269

N.B. The herd sizes in Beef Grazing A and B were based on cows + replacement heifers and steers from Table 4.6.

B. Materials

(1) Fodder

(a) Normal fodder crop 20 ha of oats per annum

Seed (130 kg/ha @ $0.10/kg)	$13
Fertilizer (0.5 tonne super-phosphate/ha @ $34/tonne)	$17
Additional working expenses	$ 7
Total	$37

Cost per annum = $37 x 20 = $740

(b) Purchased fodder

It was assumed that a poor season occurs once every 5 years and that fodder crop fails. To maintain the herd lucerne hay is purchased and fed out at 3 kg/head/day for 5 months. Cost of fodder is $40/tonne. Annual cost for each strategy will therefore be:-

$$\text{Beef Grazing A} = \frac{3 \times 150 \times 275 \times 40}{1{,}000 \times 5} = \$990$$

$$\text{Beef Grazing B} = \frac{3 \times 150 \times 300 \times 40}{1{,}000 \times 5} = \$1080$$

(2) Fertilizer for Pastures

Beef Grazing A. Top-dress with superphosphate at a rate of 0.25 tonne per ha at a cost of $34/tonne on 220 ha. $1,870

Beef Grazing B. Top-dress with superphosphate at a rate of 0.125 tonne per ha on 700 ha. $2,975

(3) Fuel and Oil

This was based on data from the ABCIS 1968/69 to 1970/71 (McCumstie, 1973) and 1973/74 (Bureau of Agricultural Economics, 1975b). A cost per head of $1.8 was adopted, giving $495 for Beef Grazing A and $540 for Beef Grazing B.

(4) Other Materials

These estimates were based on material costs for the Coastal region of New South Wales from the ABCIS 1968/69 to 1970/71 but excludes fuel, fertilizer, fodder and seed, and was adjusted downwards for repairs associated with motor vehicles. The cost per head estimated on this basis was $6.39 in approximately 1969/70 values. Converting this to 1972/73 prices using the index of prices paid for equipment and supplies excluding seed and fodder published by the Bureau of Agricultural Economics in its Quarterly Review of Agricultural Economics, a cost of $7.44/head was derived.

Thus the total annual costs for each strategy were estimated to be:-

Beef Grazing A = $2046

Beef Grazing B = $2232

C. Services

(1) Selling Expenses

Selling commission was assumed to be 3.5% based on data reported by Ridley (1972).

(2) Freight on Livestock

Again this was based on data for cartage, haulage and freight reported by Ridley (1972). Using a cost of $0.50/km per load of 35 head and an average haul of 460 kms, total costs of $999 and $927 were derived for Beef Grazing A and B respectively. The number of head sold per farm per annum was 152 and 141 respectively.

(3) Rates and Taxes

General shire rates were assessed on the basis of 4.2 cents per dollar of the unimproved capital value of the property which was estimated to be roughly $40/ha; that is, $1.68/ha. This was increased to $2/ha to include other rates and taxes. Thus the total cost for this item in Beef Grazing A and B will be $480 and $1,440 per annum respectively.

(4) Other Services and Overheads

Items included in this category are vetinary fees, miscellaneous contractors, accounting fees, insurance, worker's compensation, payroll tax, etc. but the costs of renting and operating a telephone were omitted. The cost was again estimated from the ABCIS 1968/69 to 1970/71 for the Coastal region of N.S.W. and adjusted to 1972/73 money values by means on the index of prices paid by the farmer for services and overheads reported in the Quarterly Review of Agricultural Economics.

Average cost per head (McCumstie, 1973)

	= \$439/191 = \$2.3
Adjust to \$1972/73	= \$2.3 x 1.2303
	= \$2.83

Total cost per annum:-

Beef Grazing A	\$777
Beef Grazing B	\$849

D. Replacement Costs

(1) Structural Improvements

(i) Fencing costs

These were based on Easter and Kingma (1975) as follow:-

Improved pasture	\$18.76/ha
Native pasture	\$11.18/ha

(ii) Watering facilities

The ratio of the value of watering facilities to fencing calculated from the ABCIS 1968/69 to 1970/71 for properties with herd sizes of 200 to 499 head (Bureau of Agricultural Economics, unpublished data) in the Coastal region of N.S.W. which was estimated to be 0.20 was applied to the cost of fencing in (i) to derive the capital cost of these facilities.

(iii) Yards and buildings

The values estimated for herd sizes of 200 to 499 head from the same survey data as in (ii) were simply updated to $1972/73 by means of the index of prices paid by farmers for equipment and supplies excluding seed and fodder.

(iv) Total value of structural improvements

The total value of structural improvements was estimated from the above to be as follows:-

Beef Grazing A	$13,044
Beef Grazing B	$17,302

The annual cost of replacement of these items was simply determined by dividing the total value by the estimated life which was assumed to be 20 years. Thus the allocated cost in the case of Beef Grazing A was $652 per annum and for Beef Grazing B, $865.

(2) Bulls

(i) Beef Grazing A

Based on the assumptions of a working life for a bull of 6 years and the number of bulls required equal to 6, and a sales value of $300 per bull at the end of the assumed working life, the annual cost of replacement will be $600.

(ii) Beef Grazing B

Based on the same assumptions as (i) but increasing the number of bulls to 8, the annual cost of bull replacement is $800.

(3) Mobile Equipment

Motor vehicles were not considered in the investigation since it was considered that the costs would have been incurred in any case irrespective of the occupation of the farmer. However the amount of tax saved through claiming depreciation as a taxable item constitutes a transfer payment from the government and therefore should be added to costs. This transfer was calculated by adopting an average tax rate of 30 cents/$ and a straight depreciation rate of 15% on an assumed original purchase price of $4,000; that is, an amount of $180 should be included in the replacement costs.

Other plant and equipment replacement costs were based on the average estimate from the ABCIS for the Coastal region of N.S.W. using cross-sectional data for a herd size of 200 to 499 head, and adjusting to 1972/73 values by means of the index of prices paid for supplies and equipment excluding seed and fodder. This was estimated to be $6,948 which when spread over an estimated life of 7 years was equal to an annual replacement cost of $993.

E. <u>Owner-operator's Labour</u>

The average wage of $2,299 from the ABCIS 1968/69 to 1970/71 was adjusted to 1972/73 wages by means of the index paid for wages presented in the Quarterly Review of Agricultural Economics. The resulting figure was estimated to be $2,881.

F. <u>Margin for Management</u>

This was based on the value of structural improvements, mobile capital and livestock which was estimated to be $53,000 and $60,000 respectively for Beef Grazing A and B; or at 2% per annum, $1,060 and $1,200 respectively.

APPENDIX 5.1

MILL-YARD PRICE FOR RADIATA PINE PULPWOOD IMPUTED FROM PRICES RECEIVED FOR WOODCHIP EXPORTS

Australia exports virtually no woodchips of coniferous species, except for small quantities for pulping trials. Therefore it was necessary to impute a mill-yard price from export prices received by other areas in the Pacific basin, particularly the west coast United States and New Zealand. Almost the total quantity of woodchips exported from these two countries is shipped to Japan.

EXPORT PRICE FOR WOODCHIPS (E)

(a) Based on Woodchips Exported from the West Coast United States

The West Coast United States is by far the most important region exporting woodchips to Japan. Since shipments began in 1963, the average value of these exports each year has risen from $US22/BDMT free-alongside ship (F.A.S.) to almost $US33/BDMT in 1974 (Holt, 1974; U.S. Department of Commerce, 1975) but when expressed in constant 1972/73 Unites States money values using the wholesale price all products index for the United States, these prices actually showed a decline (Figure 5.1.1)

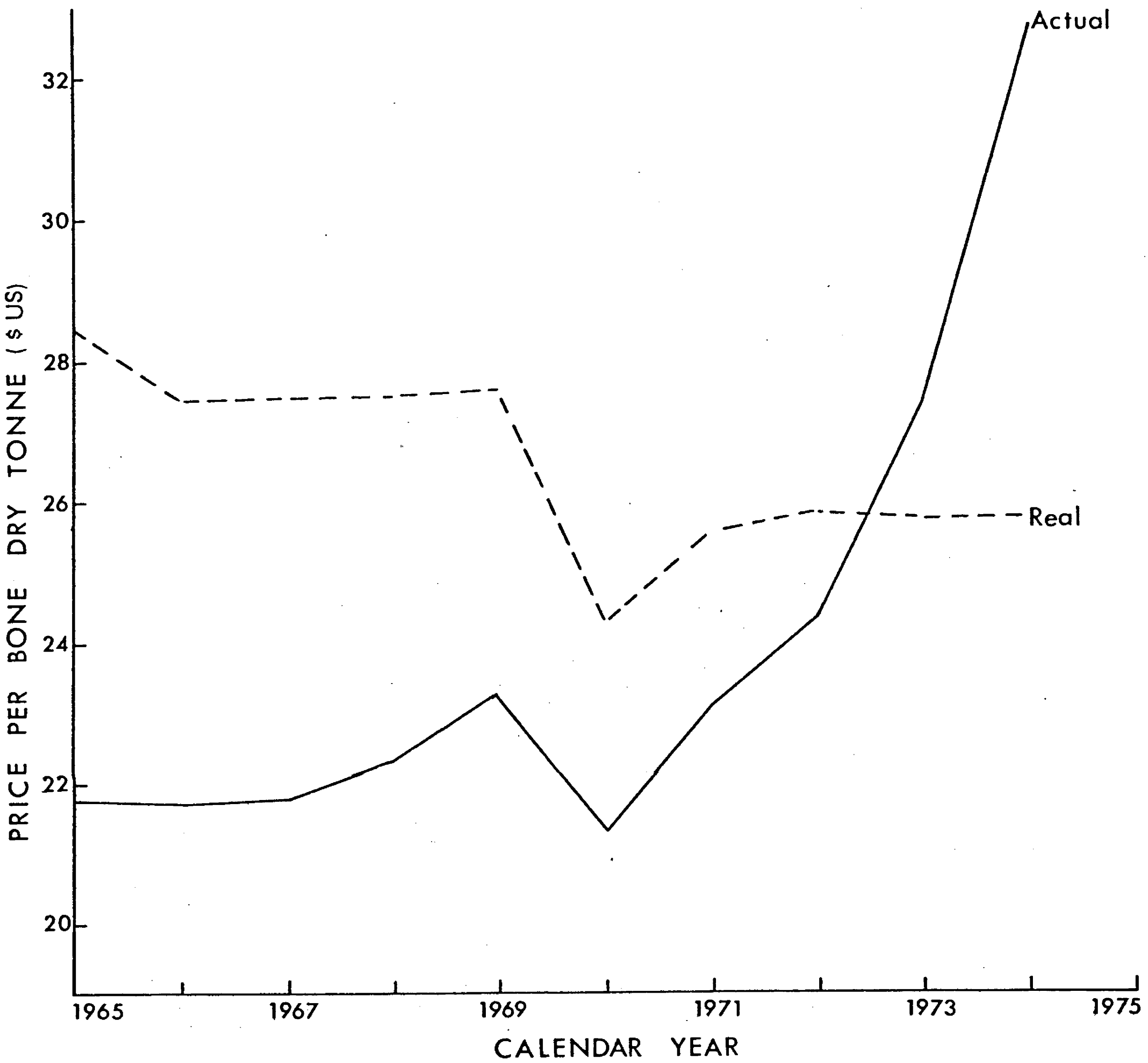

FIGURE 5.1.1 Trends in Actual and Real prices of woodchips from West Coast of United States. Real prices expressed in 1972/73 $ US

(Sources: Holt, 1974; U.S. Department of Commerce, 1975)

A trend value of \$US25.6/BDMT (about \$A20) was estimated for the base year, 1972/73, by fitting the following equation (5.1.1) to these real values:-

$$\ln p_t = 3.345 - 0.012\, t \;\ldots\ldots\; (5.1.1)$$

where $\ln p_t$ denotes the logarithm of the average annual F.A.S. value of woodchip exports from the West Coast United States in 1972/73 \$US/BDMT,

and t denotes the period in years since 1964.

The correlation coefficient for the equation was 0.75 and the value of its slope was significantly different from zero at the 0.95 probability level.

TABLE 5.1.1

Volume and FOB Values of Woodchip Exports from New Zealand during the period 1970 to 1973

Calender Year	Quantity Exported (Bone Dry Tonnes)(1)	FOB Value per Bone Dry Tonne (\$NZ)	
		Actual	Real (2)
1970	76,134	23.55	28.72
1971	93,158	23.39	25.84
1972	97,491	25.55	26.41
1973	104,931	33.14	31.64

Source: New Zealand Forest Service (1975)

(1) One bone dry unit = 1.09 bone dry tonnes

(2) Expressed in 1972/73 \$NZ

(b) Export Price for Woodchips from New Zealand

New Zealand has been exporting coniferous woodchips to Japan since 1970 but the quantities involved have been quite small when compared with the West Coast United States. However the woodchip exports from New Zealand originate from plantations of exotic conifers, including radiata pine, and therefore are more comparable with the plantations anticipated in the Lower South Coast than woodchips from the West Coast United States which originate predominantly from residues from sawmills and plymills utilizing logs from old growth Douglas fir and hemlock forests.

An average value of $NZ28/BDMT (or $A28) was estimated from average annual F.O.B. values based on quantities in the period 1970 to 1973 (New Zealand Forest Service - 1975). The average actual and real prices for this period are presented in Table 5.1.1. Since some 10 percent of the New Zealand exports are non-coniferous, a downward adjustment of $1/BDMT was made to the average real price for this period and a price of $27/BDMT was therefore settled on.

THE ADOPTED EXPORT PRICE

Greater weight was given to the price based on New Zealand woodchip exports because of their similarity in species and in wood and chip qualities to those likely to be produced from pulpwood harvested from the Region's plantations.

BASIC DENSITY OF PULPWOOD (B)

Data from two comprehensive studies, one in New Zealand (Maddern-Harris, 1965) and the other in Australia (McKinnell, 1970) were used to estimate the value of this parameter, since there was no information on basic densities for radiata pine pulpwood from the Region.

Because the Region is located at a lower altitude and a higher latitude than most Australian and New Zealand radiata pine plantations, and on the basis of patterns in basic density observed by Maddern Harris (1965), a relatively high basic density seemed likely. The adopted basic density of 0.42/tonnes/cubic metre was therefore regarded as probably conservatively low since it was based on McKinnell's (1970) estimates of the average basic density of 14 year old radiata pine from plantations located at approximately the same altitude but 1.5^{o} latitude further south of the Region in Victoria.

COST OF CHIPMILLING (C)

Chipmilling includes woodyard operations, chipping and conveyorisation from the chipper to the chip pile and from the pile to the ship. The cost of chipmilling was estimated to be $2.95/m^3 of chips and was derived from confidential data supplied to the author. In addition to wages, depreciation of plant and buildings, materials, services and administrative overhead, it also includes provision for profit in the form of a return on capital invested but its magnitude was unknown. The components comprising this cost are summarized in Table 5.1.2.

TABLE 5.1.2

Estimated cost of production of chipping, stockpiling and conveyorisation of radiata pine chips

Cost Item	\$ per m^3
Pulpwood yarding	.30
Debarking	.50
Chipping	1.00
Stockpiling and conveyorisation	.60
Overhead (plus an estimated \$0.10/m^3 for wharf costs)	.55
	2.95

Comparison with costs for independent overseas studies tends to confirm this as being a realistic estimate. Crook (1967) estimated the safe range for costs of debarking and chipping at a pulpmill in the southern United States to be \$US2.50 per cord or, expressed in 1972/73 Australian money values, an average value of \$1.00/m^3, assuming 2.27 m^3/cord and using the wholesale price all products index for the United States to convert the reported values to 1972/73 United State prices and an exchange rate of \$US1.284 per \$A1.00 (Australian Bureau of Statistics 1974 e).

The difference of $1.95/$m^3$ was considered to be more than adequate to cover the costs of maintaining the chip-pile and chip conveyorisation which Croon and Frisk (1972) estimated to be $US.77/BMT of chips or $US.35/$m^3$ of pulpwood using 2.4 m^3/tonne conversion factor.

Stuckey (1969) calculated the cost of chipping and mill handling to be higher at $US4.699/cord or expressed in 1972/73 Australian currency, $1.99/$m^3$. This still leaves $0.96/$m^3$ to cover conveyorisation to the ship and maintenance of the chip pile which is still considered to be more than adequate.

RECOVERABLE FIBRE FACTOR (R)

Losses in useful fibre due to screening and outside chip storage were estimated to be 5% based on data reported by Bergman (1972), Croon and Frisk (1972) and Dillner (1972). Thus a recovery factor of 0.95 was adopted.

THE SHADOW PRICE OF RADIATA PINE PULPWOOD

The price of radiata pine pulpwood delivered to the chipmill yard was estimated to be $7.97 per m^3. Its derivation is shown in Table 5.1.3.

TABLE 5.1.3

Estimated residual value of radiata pine pulpwood in woodyard at chipmill based on the export price of woodchips

	Item	$
(1)	F.O.B. export price of radiata pine woodchips at Edrom per bone dry tonne (P)	27.00
(2)	F.O.B. export price of radiata pine woodchips at Edrom per cubic metre sold of pulpwood (1) multiplied by .42, the basic density (B) of the pulpwood	11.34
(3)	Cost of chipmilling and wharfhandling (M)	2.95
(4)	Residual value of pulpwood at the chipmill ((2) minus (3))	8.39
(5)	Conversion to gross volume through adjustment to fibre lost during chipping and storage (4) multiplied by .95, the value of R	7.97

APPENDIX 5.2

MILLYARD PRICES FOR RADIATA PINE PULPWOOD IMPUTED FROM THE IMPORT REPLACEMENT PRICE OF BLEACHED KRAFT PULP

The adoption of a bleached kraft pulpmill was based on the following reasons:-

(i) Firstly, eucalypt woodchips currently exported from Australia to Japan are mostly manufactured into bleached kraft pulp (Watson et al.,1974) and since the pulpmill will be more heavily dependent on eucalypt pulpwood during its initial stages of production, it is reasonable to assume that a bleached kraft pulpmill will be established. Bleached kraft pulp represents almost half of Japan's pulp imports (Ministry of Finance, Japan, 1974).

(ii) Secondly there is no technical reason why the utilisation of pulpwood from radiata pine plantations cannot be successfully integrated with the production of eucalypt pulp. In fact, Australian Paper Manufacturers Limited Pulpmill at Maryvale, Victoria, has been operating on such a basis for some years.

It was further assumed that production of bleached kraft pulp from radiata pine pulpwood could be marketed in Australia and that therefore the cost of importing this grade of pulp (or its close substitute) into Australia was the appropriate basis for shadow pricing purposes. Long-fibre pulps, particularly kraft pulp, have always represented Australia's main pulp imports, either as raw pulp or in the form of paper and paperboard. In 1972/73, for example, 195,917 tonnes of long-fibre kraft pulp were imported into Australia out of a total of 317,220 tonnes of pulp imports (Australia Bureau of Statistics, 1974d).

Although it was not possible to identify the main grades incorporated in paper and paperboard imports, almost half the total quantity of imports which amounted to almost 600,000 tonnes in 1972/73 (Forestry and Timber Bureau, 1975) would have consisted of this grade.

FREE-ON-BOARD PRICE OF BLEACHED KRAFT PULP (Y_i)

The F.O.B. price at country of origin was estimated from the values and quantities of bleached kraft long-fibre pulp imported into Australia from New Zealand and Canada, the latter being the main source of supply. Even though they make up a relatively minor part of the imports of this grade of pulp to Australia, shipping only 4,301 tonnes in 1972/73 compared with 65,230 tonnes from Canada (Australian Bureau of Statistics, 1974d), New Zealand imports were considered more relevant because they are manufactured principally from radiata pine and therefore would be more representative of the Region's output than the Canadian imports. Furthermore, only one grade is understood to be involved in the New Zealand imports whereas a variety of grades are reportedly imported from Canada, some of which may not be technically feasible to produce from the Region's pulpmill. Finally, the strong link between the Australian and New Zealand currencies eliminates much of distortion to prices induced by exchange rate fluctuations experienced in recent years in other countries. In the final analysis, however, neither source was considered to be sufficiently satisfactory for adoption on its own so that estimates of both were made, and the mean of the two values adopted as the import replacement price.

Estimation of a Trend Value

The trends in actual and real wholesale prices for bleached kraft pulp in the United States for the period 1960 to 1973 (Figure 5.1), the only relatively long term price series for this grade of pulp available to the author, portray the cyclical nature of these prices. Therefore a trend rather than actual value for the year 1972/73 was considered necessary particularly in view of the fact that in 1972/73, the base year, world pulp markets were just beginning to emerge from recession.

However price data for imports from Canada and New Zealand did not extend over a long enough period for estimation of a meaningful trend value.

Therefore rather than adopt the actual price for these imports in the year 1972/73 since each reflected the depressed market conditions of that time, the mean of the prices for one complete cycle was adopted, with the cycle beginning in the late 1960's when pulp prices reached their lowest level for well over a decade and ending in the year 1973, approximately at the time when prices began to recover from the depressed market of the early 1970's.

IMPORT REPLACEMENT PRICE OF NEW ZEALAND IMPORTS
AT EDROM

The averaging period adopted for New Zealand imports was 1968/69 to 1973/74 with prices in the years up to 1970/71 based on the average annual f.o.b. values of bleached kraft pulp imports cleared for home consumption, and for subsequent years, on the average f.o.b. value of long-fibre pulp only (Commonwealth Bureau of Census and Statistics, Australia, 1969, 1970, 1971, 1972, 1973a; Australian Bureau of Statistics, 1974a and 1975a). The average price derived from these values, expressed in 1972/73 dollars using the Consumer Price All Groups Index for Australia, was $A135.4 per airdry tonne.

Freight Cost (F)

The cost of freight between New Zealand and Sydney was estimated to be $33.85/BDMT and was based on general shipping cargo rates operating in 1972/73 (Commonwealth Bureau of Census and Statistics, Australia, 1973 c and d).

Cost of Wharfage, Unloading and Transport to Papermill (W)

A cost of $11/ADMT was allowed for discharge of cargo, wharf-handling and transport costs from the wharf to the papermill. This was assumed to be equal to the cost of transporting pulp from Edrom to the papermill near Sydney. In all likelihood, however, a the papermill would be integrated with the pulpmill at Edrom because of the cost economies involved (reduced handling costs, savings in fibre and so on) and therefore, the cost of transport from Edrom to the papermill (T) would probably be considerably less than the cost of W because of these economies. In the following calculations, these two items, W and T, are ignored. The resulting value for the import replacement cost is probably a conservative estimate because of the fact that T is less than W.

The import replacement cost of bleached kraft pulp from New Zealand at Edrom (K + F + W) was therefore estimated to be $169.25 per ADMT.

IMPORT REPLACEMENT VALUE AT EDROM FOR CANADIAN IMPORTS

An approach similar to that for New Zealand pulp was adopted for Canadian exports to Australia, this time using official Canadian statistics on the value and quantity of exports for bleached kraft pulp for each year since 1967 when statistics on this grade were first published (Dominion Bureau of Statistics, Canada, 1968, 1969, 1970, 1971 and 1972; Statistics Canada, 1973b and 1974b). Again the average annual values per tonne for the period 1968 to 1973 expressed in 1972/73 Canadian dollars by means of the General Wholesale Price Index for Canada were meaned and the derived value of $132.00 per

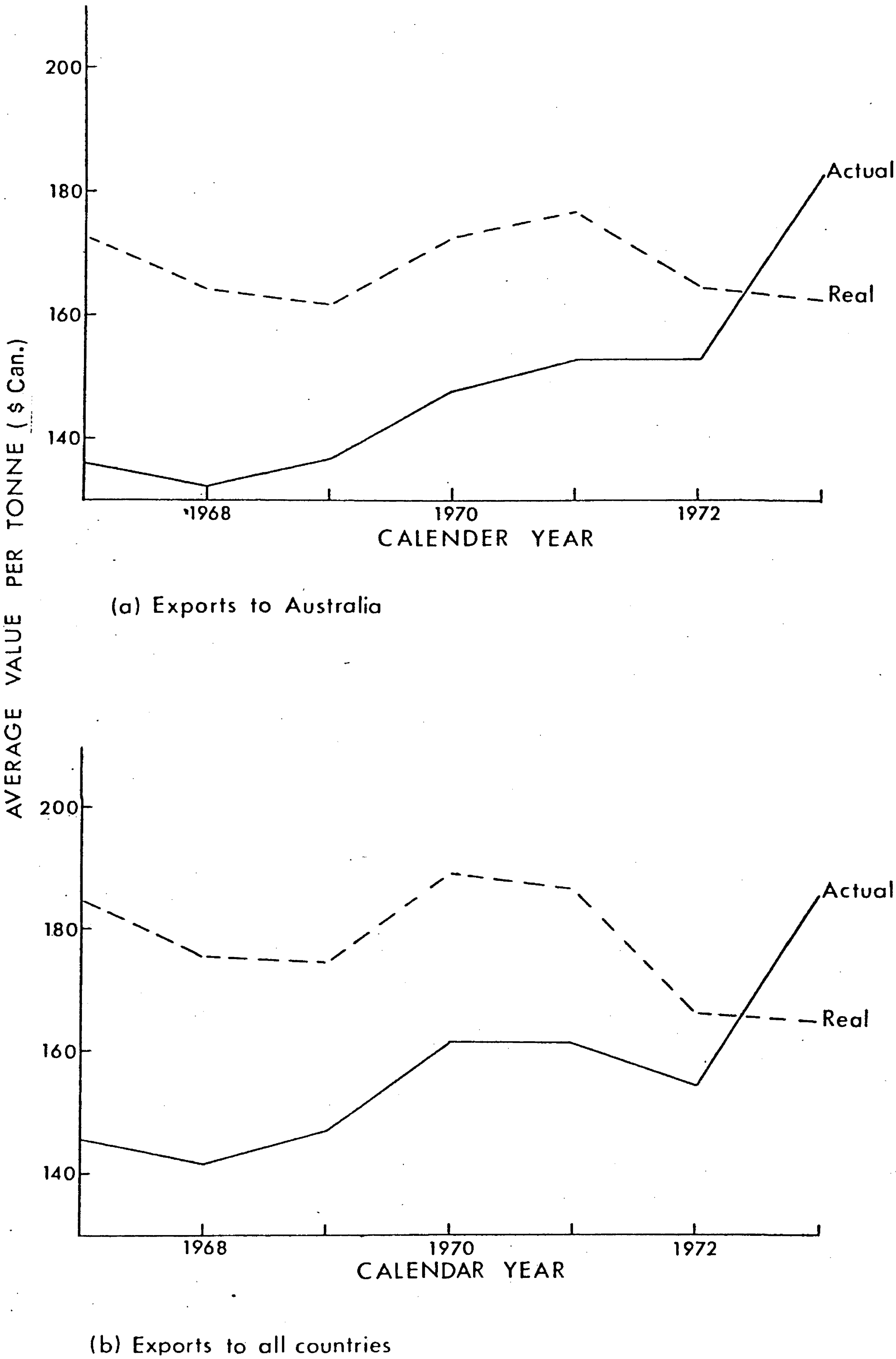

FIGURE 5.2.1 Trends in actual and real average values of exports of bleached Kraft long-fibre pulp from Canada.

ADMT was adopted as the starting point for estimating the residual value. This cycle can be seen in Figure 5.2.1, both for exports to Australia and to all countries from Canada.

However since Canadian exports are expressed in F.O.B. values place of lading and not at the port of shipment, provision had to be made for the cost of inland freight, insurance, handling and associated internal costs. Although it was not possible to collect relevant data for the estimation of these costs, they were estimated indirectly by calculating the difference between the f.o.b. value of bleached kraft softwood pulp exports to Japan from Canada (Statistics Canada, 1973 b) and CIF value of bleached kraft (softwood and hardwood) pulp imports into Japan from Canada (Ministry of Finance, Japan, 1973) in the year 1972, adjusted for the premium in price of softwood pulp over hardwood pulp not included in the CIF value and then using the derived cost to determine the cost of freight and insurance associated with shipping from Canada to Australia plus inland freight and associated costs in Canada. This was estimated to be $38 per ADMT. Again a cost of $11 per ADMT was adopted for freight from Edrom, the same as for costs of discharge, wharfage, port handling and internal transport within Australia. The landed f.o.b. price at Edrom was therefore estimated to be $170 per ADMT.

COST OF PRODUCTION OF BLEACHED KRAFT PULP (P)

The estimation of this parameter depended primarily on costs used by Australian Paper Manufacturers Ltd (1974) who based their calculations on three comprehensive studies of operating costs and capital investments relating to large bleach kraft pulpmills (Daly, 1969; Diedrich, 1967; F.A.O., 1973). As in Australian Paper Manufacturers Ltd's study the hypothetical mill was assumed to produce 263 000 air dry tonnes of pulp per annum. The estimated component costs of production per tonne of pulp for such a mill are presented in Table 5.2.1 and are examined in detail.

TABLE 5.2.1

Estimated cost of production of a large bleached kraft pulpmill

Item	Cost per tonne 1972/73 $ Aust
A. OPERATING COSTS	
Chemicals	24.00
Power and fuel	7.00
Materials and maintenance	12.00
Water (50 0001/tonne @ 10c/1000 l)	5.00
Overheads	7.30
Labour (2.0 man-hours/tonne @ $3.10/man - hour)	6.20
Salaries (92 people @ $8 000/annum)	2.80
TOTAL OPERATING COSTS	64.30
B. CAPITAL COSTS	
Depreciation (Straight line 5%; scrap value 5%)	14.30
Interest on working capital (7% of $9 million fixed term debentures)	2.40
Profit allowance (15% on average profit bearing capital $43 461 000)	24.80
TOTAL	105.80

Capital Costs

The capital investment figure of $79.2 million adopted was based on the estimate of $72 million assumed by Australian Paper Manufacturers Ltd (1974) but adjusted upwards by 10 percent to cover the rise in the general price level between 1971/72 and 1972/73 (approximately 6 percent) using the Consumer Price Index All groups for Australia plus a provision of 4 percent for increased expenditure due to more advanced technology in the mill design.

The basis for estimating depreciation costs is identical to that adopted by Australian Paper Manufacturers Ltd (1974). The profit allowance was based on a real return before tax of 15 percent per annum on the average capital investment, K, which was derived in the following manner:-

$$K = (I - R)(N+1)/2N + R \quad (5.2.1)$$

where I denotes the initial investment,
R denotes the salvage value of the pulpmill,
and N denotes the life of the pulpmill in years.

It was intended to reflect a normal profit sufficient to keep the company in pulpmilling rather than some other enterprise. It has been deliberately set higher than the marginal rate of return on private investment of 12 percent which was used earlier in Appendix 3.1 in determining the opportunity cost of capital, partly as a conservative measure and partly to include an allowance for risk which was not relevant to the earlier figure.

Interest charges on working capital were determined by assuming a value of $9 million for working capital which is equivalent to about 20 percent of the total value of pulp sales estimated to be approximately $44 million. This ratio was based on working capital/sales ratios calculated for the paper and paper products industry during the period 1970/71 to 1972/73 (Industries Assistance Commission, 1974). The working capital was assumed to be financed by fixed term debentures with a real (net of inflation) interest charge of 7 percent per annum.

Operating Costs

The cost of chemicals, power and fuel, and materials and maintenance were based on Australian Paper Manufacturer Ltd (1974) estimates, but were updated to 1972/73 values by means of the Consumer Price Index referred to previously. Adjustments were also made for additional freight costs; for chemicals, this was estimated to be $2.8/ADMT based on 0.24 tonne of chemicals (salt cake, limestone, chlorine, caustic soda, sulphuric acid etc.) per ADMT of bleached kraft pulp using data reported by FAO. (1973) and on an additional haulage distance of 400 km from Melbourne at 3 cents/tonne/km. Only small adjustments were necessary in the case of other items and updated estimates were simply rounded to the next highest dollar.

The cost of water to the pulpmill is a subjective estimate since this will depend primarily on the type of technology adopted and quality and variability of flow of the water. It was assumed for environmental reasons and limited water availability in the Edrom area that a completely enclosed kraft system will be installed and that a satisfactory water supply will be available. Twitchell and Edwards (1974) calculated that an enclosed system reduced fresh water usage to 11,700 litres/oven-dry tonne of pulp compared with 55,700 litres for an open system. A conservative rate of 50,000 litres/tonne was adopted in this study at an estimated cost of \$0.10/1000l which was based on recent costs for water supply in Australia (Stodart, pers. comm.) appropriately deflated to 1972/73 values.

The cost of overheads shown in Table 5.2.1 was based on the estimate by Australian Paper Manufacturers Ltd (1974) but increased by 11 percent to cover rises in general price levels generally (6 percent) and increased insurance charges and labour overheads (5 percent).

A productivity rate of 2.0 man-hours per tonne was adopted for mill employees based on manpower figures reported recently by Kalish (1973) for a modern bleached kraft softwood pulpmill. The cost per man-hour was based on the average earnings of \$5,394 per annum for production employees in the pulp, paper and paperboard industries in Australia in 1972/73 (Australian Bureau of Statistics, 1975b); this was estimated to be equal to \$2.59/man-hour assuming 2,080 man-hours of operating time per annum.

It was adjusted upwards by 20 percent to \$3.10/man-hour to allow for higher levels of skill assumed to be associated with the larger, more capital-intensive hypothetical pulpmill of this study. The number of administrative personnel was assumed to be 92, identical to the figure reported by Kalish (1973). An average salary of \$8,000 per annum was adopted and was based on the average annual earnings of \$6,692 by staff connected with administration, office, sales and distribution in the pulp, paper and paperboard industries in Australia in 1972/73 (Australian Bureau of Statistics, 1975b) but increased by 20 percent, again to reflect higher skill levels in the hypothetical mill.

The total cost of production, including profit, was therefore estimated to be \$105.8 per tonne. The operating costs of \$64.2/tonne is considered to be high when compared with a recent estimate for a bleached kraft southern pine pulpmill in the southern United States of America (Auchter, 1973) which expressed in equivalent 1972/73 Australian dollars was estimated to be about \$50 per tonne.

PRICE OF PULPWOOD IN MILLYARD

To determine this value the average cost of production was deducted from the mean of the import replacement prices for pulp imported from New Zealand and Canada which was estimated to be \$169.6/tonne.

The residual value resulting from this was converted to a per cubic metre of pulpwood basis by dividing it by the estimated conversion factor of 5.4 m^3 per ADMT of pulp. This factor was calculated on the basis of the following assumptions:-

(a) The same basic density of .42 tonne per m^3 which was used earlier to impute the millyard price of radiata pine pulpwood from the export price of woodchips.

(b) A yield of 42 percent of bleached kraft pulp based on a recovery of 45 percent for unscreened unbleached sulphate pulps from radiata pine pulpwood (Nelsen et al 1973) and a loss of 3 percent from bleaching.

(c) A fibre loss from chipping and outside storage of chips of 5 percent, as estimated previously for application to the imported price of pulpwood based on the export price of woodchips.

The imputed price of radiata pine pulpwood in the millyard at Edrom was therefore estimated to be \$11.81 per m^3 as shown in Table 5.2.2. Since no adjustment was made for the moisture content of the air dry pulp, the conversion factor is obviously too high and therefore the millyard price is lower than it ought to be. However, because shipping costs seemed high, this conservative approach seemed justified.

TABLE 5.2.2

Average residual value of pulpwood in millyard based on the landed cost of bleached kraft pulp

Item	1972/73 $A
A. Per Air Dry Tonne of Pulp	
a. Value of pulp Edrom	169.60
b. Cost of production	105.80
c. Residual value of pulpwood at millyard (a-b)	63.80
B. Per cubic Metre of Pulpwood Residual value of pulpwood at millyard (c divided by 5.4 cu m per air dry tonne)	11.81

APPENDIX 5.3

CALCULATION OF STUMPAGE PRICES FOR RADIATA PINE PULPWOOD

Stumpage prices were calculated by deducting the cost of harvesting (L_i) from the millyard price for the pulpwood.

Cost of Harvesting (L_i)

Harvesting encompasses all those operations associated with extracting the tree from the plantation and delivering it to the mill. Two main pulpwood harvesting systems are commonly used in Australian conifer plantations: (a) the billet system and (b) the long length system (Goudie, 1971). For this study it has been assumed that either system can be operated, with the final decision resting primarily on the average diameter breast height over bark of the trees being harvested.

TABLE 5.3.1

Estimated cost of hauling radiata pine pulpwood

Item				
1.	Owning Costs (cents/km):-			
	1.1 Depreciation:	Prime mover Jinker		4.92 0.54
	1.2 Insurance:	Prime mover Jinker		0.83 0.08
	1.3 Registration			0.20
	1.4 Profit			3.07
2.	Operating Costs (cents/km)			22.25
3.	Wages			5.42
4.	Overheads			3.62
			TOTAL	40.93
Total Cost/m^3/km				3.39

Studies by A.P.M. Forests Pty Ltd. (Hall, 1974) indicate that higher per unit costs are associated with smaller average diameter of thinnings. Costs in this study have thus been based on the modal d.b.h. class predicted in the supply alternatives adopted. Using data reported by Hall (1974) the cost of felling, trimming, cross-cutting, stacking or skidding and loading onto trucks was estimated to be \$3.83/m^3. This was raised to a round figure of \$4.50/m^3 to cover costs incurred by plantation owners with respect to the selling of the pulpwood (sales appraisals, marking and measuring operations and so forth) and with supervision of the logging operations, estimated to amount to 10 percent of Hall's costs and to allow for an estimated $0.25/m^3 for unloading and turnaround.

A flat rate of 3.5 cents/m^3/km was adopted for haulage costs. It was based principally on estimates calculated by De Vries (1973) for a $30,000 tandem-axle prime mover and a $4,000 trailer, for an average haulage distance of 100 km and assuming a fully sealed road connects each Management Area to the mill at Edrom.

The total distance travelled per annum was estimated to be 100,000 km approximately and was based on a minimum of 1,580 hours worked per year, 2.5 hours/week downtime for repairs and maintenance, turnaround and Main Roads Department inspection of 0.75 hour/trip and an average speed into the mill of 50 km/hour and of 80 to 90 km per hour on the return empty journey.

A detailed analysis of the individual components included in this rate is presented in Table 5.3.1. Owning and operating costs were based on Appendix 7 in De Vries (1973) but using a distance travelled per annum of 100,000 km in place of his 40,000 miles. The only major difference was the inclusion of a profit margin of 15% in lieu of the interest rate of 8% which was assumed by De Vries.

The driver's wage was assumed to be equal to the average earnings in the Transport and Storage Industry in October, 1972 which was $5,542 and included overtime of 6.2 hours/week plus incentives, bonuses etc. (Commonwealth Bureau of Census and Statistics, 1973b). Overheads were subjectively assessed to be 66 2/3% of the driver's wage and includes a loading of 25% for worker's compensation based on the maximum rates applying to the logging industry in New South Wales in 1972 and 1973 (FORWOOD, 1974 b).

A cost of 3.39 cents/m^3 was estimated and was rounded up to the 3.5 cents/m^3/km to cover unforeseen contingencies. It was derived by dividing the total cost of 40.93 cents/km by a factor of 24 m^3/load for pulpwood. This conversion factor assumed a basic density of 0.42 tonne/m^3, a moisture content of 100% and an allowance of 10% by weight for bark.

Stumpage Prices

The stumpage prices for pulpwood at each Management Area, i, were derived for the pre- 1995/96 and 1995/96+ as follows:-

$$\text{Pre- 1995/96:} \quad P_i = 7.97 - L_i \qquad (5.3.1)$$

$$\text{1995/96+:} \quad P_i = 11.81 - L_i \qquad (5.3.2)$$

where P_i and L_i are as defined previously in equations (5.3.1) and (5.3.2) and $7.97 and $11.81 are the mill-yard prices for pulpwood based on respectively (i) the export prices for woodchips and (ii) the import replacement price for bleached kraft sulphate pulp. Where pulpwood is harvested prior to the year 1995/96, the pre- 1995/96 price was adopted as the most likely value; when harvested subsequently from 1995/96 onwards, the 1995/96+prices were adopted.

Unfortunately it was not possible to compare the imputed prices with stumpages charged by the Forestry Commission in the Region since no sales of plantation thinnings for pulpwood have been made to date. However in the FORWOOD Panel report on harvesting (FORWOOD, 1974b), a stumpage value of $\$2/m^3$ was considered to be typical based on an average haul of 40 km. This figure is higher than the pre-1995/96 stumpage prices and less than the 1995/96+ prices.

APPENDIX 6.1

CALCULATION OF IMPORT REPLACEMENT PRICE OF SAWLOGS IN MILL YARD

IMPORT REPLACEMENT PRICE OF SAWNTIMBER AT KEYMARKET (I)

Import replacement price has been adopted as a starting point for residual value calculations. Most imports, especially those used for house framing (potentially the most important market for both native timbers and radiata pine) have traditionally come from North America. Australia is clearly a price-taker in the North American market and the f.o.b. prices of North American exports are established in markets which generally are acknowledged to be freely competitive (Ferguson and Parkes, 1976). Consistent with the approach for other products in this study, however, import replacement price has been estimated free of tariff protection.

Douglas fir framing[1] was the obvious choice for this purpose.

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[1] Throughout this analysis prices for sawlogs, whether pruned or unpruned, have been based on Douglas fir framing even though a premium would normally be paid for clear grades sawn from the pruned logs. Thus the stumpages adopted for pruned sawlogs will be extremely conservative.

The Working Party on Douglas fir (1972) estimated that Douglas fir constituted about 23% of the volume of light framing timber used in New South Wales in 1968, and it must have comprised well over 30% of the volume of light framing timber used in Sydney. Douglas fir has long been the most important single species in this market and it has only been in the last decade that other North American species have made inroads. In addition it was not possible to obtain reliable historical data for the prices of these other species in North America in the relevant grades and sizes.

Most Douglas fir from North America has been imported in large baulks, or flitches, which attracted lower tariffs. These baulks were resawn by Sydney merchants to reduce the total volume of stocks otherwise needed. Unfortunately because reliable data on the product mix and cost of resawing were not available, the residual value calculations could not be based on imported baulks.

Recent changes in exchange rates and tariffs, notably the 25% cut in tariffs in 1973, have encouraged a shift towards imports in finished sizes. This shift has been assisted by the revision of the Light Timber Framing Code in Australia to incorporate North American specifications and sizes (Lembke, 1975), which were previously unacceptable. Further increases in imports in finished sizes are expected since many mills on the West Coast of North America cut exclusively to these specifications.

The ability of finished sizes to compete with material resawn from baulks, despite the present tariff differential of about \$6.67 per m^3, suggested that the duty-free landed price of finished sizes would provide a satisfactory starting point for residual value calculations, but the derived values are likely to be somewhat conservative.

TABLE 6.1.1

Sizes and lengths of Douglas fir and radiata pine sawntimber used as framing in a typical house.

Item	Douglas fir sizes (mm)		Radiata pine in finished sizes(mm)	Length Required (m)
	Nominal	Finished		
1. Floor Framing				
Plates & bearers	152x76	139.7x63.5	140 x 60	89
Floor joists	102x51	88.9x38.1	90 x 45	270
2. External walls				
Plates	102x51	88.9x38.1	90 x 45	85
Studs	102x51	88.9x38.1	90 x 35	207
Studs	102x76	88.9x63.5	90 x 70	24
Nogging	102x51	88.9x38.1	90 x 35	137
3. Internal Walls				
Plates	102x38	88.9x31.7	70 x 45	87
Studs	102x38	88.9x31.7	70 x 35	293
Nogging	102x38	88.9x31.7	70 x 35	122
4. Ceiling framing				
Joists	102x38	139.7x31.7	120 x 35	147
Benders	203x51	184.2x38.1	190 x 35	24
5. Roof framing				
Rafters	102x76	88.9x63.5	90 x 70	175
Battens	76x38	63.5x31.7	90 x 35	297

Technical Substitution

The use of Douglas fir as a basis for the import replacement price assumes that Douglas fir and radiata pine are perfect or near-perfect technical substitutes in house framing. Unfortunately however, the specifications for the two species differ since Douglas fir is specified in terms of the nominal green-off-saw size whereas radiata pine is specified in terms of finished size. Partly because of the necessity to specify sizes in convenient multiples to suit local market requirements, and partly because of inherent differences in strength characteristics, differences in the finished sizes of the two species have been accentuated by the recent metrication of sizes in Australia. Thus more timber of one species than that of the other could be used for a particular house frame.

The specifications and quantities of Douglas fir and radiata pine have been calculated for a timber-framed house of 120 m^2 floor area, based on the sizes specified under the Light Timber Framing Code for these species, and on the minimum permissible finished sizes for Douglas fir specified by the West Coast Lumber Inspection Bureau (1970). These data are shown in Table 6.1.1.

Despite some obvious differences in the finished sizes in Table 6.1.1, the total finished volume of Douglas fir is 7.112 m^3 compared with 7.318 m^3 for radiata pine, a difference of only 2.9 percent. Thus it seems reasonable to regard the two species as perfect technical substitutes in the aggregate situation.

A representative size and grade

The selection of a specific grade and size, or set of grades and sizes, to establish an average or representative landed price for Douglas fir in Sydney raises several difficulties. Ideally one would like to obtain prices for all the grades and sizes which would result from sawing radiata pine so that a weighted average price for radiata pine could be calculated. This was not feasible because

1. comprehensive data on the product mix from sawing radiata pine were not available,
2. the sizes and especially the grades for radiata pine and Douglas fir did not correspond exactly, and
3. suitable price series for such a wide range of Douglas fir sizes and grades were not available.

The approach adopted in this study was therefore to select a single size and grade of Douglas fir framing judged to be representative for the purposes of pricing the average out-turn for radiata pine. Although subjective, this approach seemed preferable to attempting to interpolate, extrapolate and generally to stretch together a veneer of data which were patently incomplete in relation to the population as a whole and markedly variable in accuracy.

The price series chosen was based on monthly quotations of the price of kiln-dried Dimension (i.e. light framing), construction grade timber, 102 mm. by 51 mm. nominal size, dressed on all four sizes (S4S) in random length mixed dimension carloads (rail), f.o.b. at sawmill in the United States - hereafter referred to as "Construction Grade framing".

TABLE 6.1.2

Industry estimates of proportion of out-turn by grades from milling radiata pine in South Australia in 1980.

Grade	Products	Source of Sawlogs		
		Second thinning	Third thinning	Clear-felling
Select	Linings, claddings fascias	5%	10%	10%
Joinery	Mouldings, joinery	5%	10%	15%
Standard	Flooring, dressed battens, furniture	45%	10%	10%
Standard building and standard	Structural timbers	15%	55%	55%
Engineering	Studs	20%	10%	5%
Packaging	Case, industrial packaging	10%	5%	5%

Source: FORWOOD(1974 c) Table 4, data for 1980.

TABLE 6.1.3

Proportion of out-turn from milling radiata pine by stress grades.

Stress Grade	Proportion of out-turn from trees of age		Comparable grade for Douglas fir
	25 years + (Cotton 1975)	35 years (Brick 1969)	
F11 to F17	-	19.3	Structural to select
F7 and F8	18.78	24.1	Construction
F5	30.66	29.3	Standard and better
F4	40.38	15.7	Standard
F3) Other)	10.18	11.6	Utility, reject or undersize
	100.00	100.00	

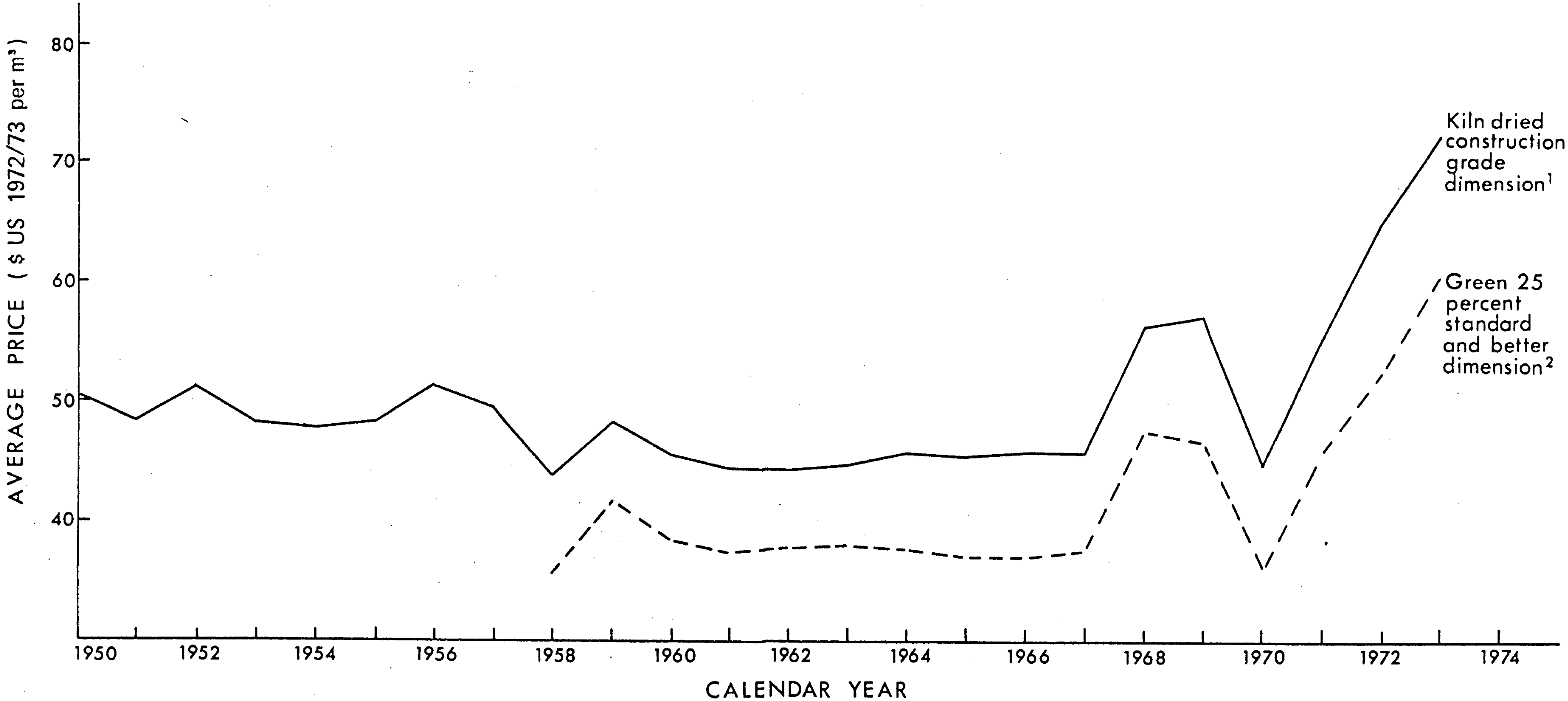

FIGURE 6.1.1 Trends in real prices of Kiln dried construction and Green 25 percent standard and better dimension grade Douglas Fir, 102 x 51 mm = nominal size, FOB mill, United States.

(Sources: 1. Kiln dried construction grade dimension prices: Survey of Business Statistics, U.S. Department of Commerce 1958 to 1974
2. Green 25 percent standard grade and better dimension: Hamilton 1968; Holt 1974)

Monthly prices for this product are published by the U.S. Department of Commerce in its Survey of Current Business, the prices representing the average of quotations from various sellers (at least three) for one day of the month. This price series was deflated to provide real 1972-73 values using the Wholesale Price Index for all commodities again from the Survey of Current Business.

The two main price series available, Construction grade framing and Green 25% Standard and better grade framing, are shown in Figure 6.1.1. Not unexpectedly, the two are closely related. Construction grade framing was chosen in preference to the other because its price seemed likely to be more representative of the average price for radiata pine, given the substantial volume of better quality, higher priced material produced in the radiata pine plantation strategies, particularly those involving pruning.

Industry estimates of the proportion of various products expected to result from milling radiata pine in 1980 are shown in Table 6.1.2. These estimates are broadly in agreement with two detailed studies of out-turn from milling radiata pine in which the sawntimber was stress-graded. The study by Australian Timber Industries Pty. Ltd. (Cotton, 1975) involved mainly third and later thinnings (25 years or older), while Buick's (1969) study consisted of 35 year old trees. The results of these two studies are shown in Table 6.1.3, together with corresponding grades for Douglas fir.

Thus construction grade framing should provide a reasonable although possibly conservative basis for pricing sawntimber processed from later thinnings and clearfallings by a sawmill producing principally framing grades. Some adjustment to this price will be necessary for the smaller-sized trees in earlier thinnings, however, in order to take into account the expected lower out-turn of higher stress grades.

The Trend Value

As with other products examined in this study, there have been cyclical fluctuations in the price of timber (see Figure 6.1.1).

Thus a trend value for Construction grade framing was estimated from the following equation, which was fitted by least squares regression:-

$$\ln P_t = 3.7781 + 0.0114\, t \quad \ldots\ldots (6.1.1)$$

where $\ln P_t$ denotes the logarithm of the average annual price for Construction grade framing in 1972/73 \$US/m^3; and

t denotes the number of years since 1952.

This equation has a correlation co-efficient of .53 and the slope value was significantly different from zero at the .95 probability level. The resultant trend value for the average price of Construction grade framing in 1972/73 was \$US55.25 per m^3. This was well below the actual values of \$US64.80 and \$US73.43 per m^3, in 1972 and 1973 respectively. However these latter values resulted from the concurrent boom in the building sectors of all the major Western economies at the time.

The average rate of increase from 1953 to 1972 was 1.15% per annum, which is lower than estimates of past trends over longer periods for coniferous timber in general in the United States.

Shipping Costs

Historical data for the costs of shipping timber to Australia were not available but current or near-current estimates were available. The cost of packaging was estimated to be $US1.80/m^3, based on estimates by Host (1969), adjusted to 1972/73 values.

The cost of freight, other handling from sawmill to wharf in the United States, and wharfage was estimated to average $US3.00/m^3 based on data supplied by the Australian importing subsidiary of a major United States firm. Thus the free along-side ship (f.a.s.) price for construction grade framing was estimated to be $US60.05/m^3.

An average cost of $US23.40/m^3 was adopted for loading, freight and insurance from the west coast of the United States to Sydney. This figure was based on data supplied to hearings of the Joint Parliamentary Committee on Prices (Gollin Holdings Ltd., 1973), adjusted downwards by 10% to allow for the lower costs associated with dressed kiln-dried timber compared with the green rough-sawn basis of the original data.

The average cost of landing, wharfage, quarantine, and importer's commission was also based on data supplied to the Joint Parliamentary Committee by Gollin Holdings Ltd. (1973). These data indicated that the cost of import duty, landing, wharfage, quarantine and commission averaged \$A25.17/m^3 on a total volume of 344 m^3. Deduction of import duty and the 4.5% cash discount allowance incorporated in this figure yielded an average cost of \$A15.10/m^3. However this figure had to be further adjusted to allow for the fact that the importer's commission included in it is based on baulks of timber which have a much higher average landed price per unit volume than Construction grade framing. Importer's commission is 5% of the landed c.i.f. price, which was \$A104.48/m^3 on Gollin Holdings Ltd. data, compared with an estimated c.i.f. price for Construction grade framing of \$A64.99/m^3. Adjusting the commission to the latter basis involves a reduction of \$1.97/m^3, resulting in a final figure of \$A13.13/m^3 for landing, wharfage, quarantine and commission.

The cost of transport which includes loading and cartage from wharf to merchant's yard was estimated to be \$2.48/m^3 based on then current quotes of transport costs, giving a final landed duty-free price of \$A80.60/m^3 at merchant's yard.

Adjustments to Base Price

The trend value of $80.60/m^3 was assumed to represent the price for the average out-turn of framing timber from low-pruned trees. However it was not considered to be indicative of the price for the average out-turn from some other sizes and grades of trees. Thus some adjustments to this base price seemed to be necessary.

Adjustments for different tree sizes were necessarily subjective since very few data are available. The trend value of $80.60 per m^3 was considered reasonable for trees over 35 cm d.b.h. since the average sizes of trees from fourth and later thinnings and from clearfellings in the strategies adopted in this investigation (see Appendix 4.1 for details on d.b.h. of thinnings and clearfellings) are of this order. However it was reduced by 10 percent for trees between 30 and 34.9 cm and by 15 percent for trees less than 30 cm d.b.h. to take into account the greater proportion of low density wood inherent in these smaller size classes. These are presented in Table 6.2.

No adjustments were made for improvements in wood quality due to a higher pruning largely because insufficient data were available. In any event in Forestry C high-pruning would be partly negated by larger-branch sizes in the unpruned sections of the high-pruned trees.

FREIGHT COSTS FOR SAWNTIMBER

Two logical sawmill sites were assumed - one at Bega for the coastal plantations and the other at Bombala for Tableland plantations. Sawmilling for radiata pine is already being carried out at Bombala but the annual log intake is still relatively small, currently about 15,000 to 20,000 m^3 per annum.

Haulage costs for radiata sawntimber from each mill to the keymarket at Sydney were based on data reported in the E. & M. Bulletin of the Forestry Commission of New South Wales. This schedule is used in stumpage appraisals of sawlogs from the Commission plantations. The schedule operative from the 1st July, 1973 was adopted since the costs set out therein were comparable with costs quoted by timber-merchants dealing in radiata pine sawntimber in the Sydney and Canberra markets. The distance to Sydney and the associated total freight costs are shown in Table 6.3.

COST OF SAWMILLING

The cost of sawmilling for radiata pine was based on a hypothetical sawmill of modern design specializing in the manufacture of kiln-dried and dressed timber. Comparatively few mills of this size and design exist in Australia because plantation production has generally not reached a sufficient level to support them. Hence actual data on costs were not available.

There is evidence (Mead, 1966; Reilly, 1971; and Watt and Douglas, 1974) which suggests that economies of scale may exist for mills of this type. On the basis of these studies a hypothetical sawmill capable of producing 220 m^3 per eight (8) hour shift was used to estimate costs.

TABLE 6.1.6

Estimated annual and average costs of sawmilling ($ / year and $ / m^3 respectively).

Item	One shift per day operation	Two shifts per day operation
Capital and administrative costs		
Depreciation	253,575	298,125
Administration	105,000	132,000
Insurance	36,416	43,131
Interest on working capital	45,846	91,692
Profit Allowance	273,118	323,984
Operating Costs		
Labour	542,492	1,121,157
Labour Overheads	108,498	224,231
Maintenance	126,788	268,313
Supplies	105,798	211,596
Power and fuel	125,950	231,748
Total	1,723,481	2,945,977
Average total cost ($ / m^3)	34.21	29.24

This is consistent with capacities in use in the Southern United States under conditions similar to those for radiata pine (Reilly, 1971) and corresponds to the output reported for a recently completed sawmill producing radiata pine framing in Victoria (Lembke, 1974).

Costs have been calculated both for operations based on one 8 hour shift per day and for operations based on two eight hour shifts per day. The component costs are summarized in Table 6.1.6.

Capital and Administrative costs

A capital investment of $3,080.000 was assumed for the hypothetical sawmill including $350,000 for buildings and site preparation. It excludes any duty on imported items. This represents $14,000 per m^3 sawn output for one-shift day and was based on investment expenditures reported in Australia and overseas for similar mills. For two-shift operations a further $570,000 of investment was added to this figure, including a further $100,000 for buildings and site works. All figures incorporate a loading of 15 percent on direct expenditure to allow for interest charges and other costs incurred during the construction and start-up period.

The depreciation costs shown in Table 6.1.6 were based on a straight line allowance assuming a life of 10 years in the case of sawmill plant and machinery, and a salvage value of 10 percent.

This is identical to the assumption adopted by Dobie (1967) for a large Canadian sawmill. An estimated 40-year life plus a salvage value of 10 percent was assumed for buildings, improvements etc.

Administration costs in Table 6.1.6 were based on one mill manager earning $15,000 per year; three administrative officers (an accountant, a sales supervisor and a logging manager) each earning $10,000 per year; six office staff averaging $5,000 per year; overheads (superannuation contribution, payroll tax, workers' compensation, long service leave etc.) equal to 20 percent of salaries; and miscellaneous office expenses totalling $15,000 per year. The composition of the staff was based on the author's observations of sawmills in the southern United States and Australia. Industry personnel in Australia confirmed the salary estimates adopted; however the average salary of $7,500 per staff member is considerably higher than the average amount earned by administrative, office, sales and distribution employees in the log sawmilling industry (excluding working proprietors and any amounts drawn by them) of $5,681 per year in 1972/73 (Australian Bureau of Statistics, 1975b).

Insurance charges vary according to the risk involved which differs between type of mill, locality and management. On the basis of rates quoted by insurance companies, a charge of 2 percent per annum on the average capital investment, which was estimated in the same way as shown in Appendix 5.2.

Interest charges on working capital were estimated by assuming that working capital amounted to 20 percent of total annual turnover which was the industry average in Australia from 1970 to 1973 (Industries Assistance Commission 1974). This working capital was assumed to be financed by fixed term debentures with a real (net of inflation) interest charge of 7 percent per annum.

As for the cost of bleached kraft pulp production in Chapter 5, the profit allowance was based on a real rate of return before tax of 15 percent per annum on the average capital investment.

Operating Costs

Direct labour costs were based on an average rate of $2.66/man - hour of actual working time. This figure originated from a survey of average weekly earnings in 1972/73 for adult males in the "Other Manufacturing" industry grouping which contains sawmilling (Commonwealth Bureau of Census and Statistics, Australia, 1973b). It includes payments for overtime at the rate of 5.4 hours per week, as well as bonus and incentive payments and is well in excess of the average earnings of $1.71/hour estimated for log sawmilling in 1972/73 (Australian Bureau of Statistics, 1975b). However it was considered more likely to be representative of transfer earnings for the relatively skilled work required in a sophisticated sawmill of this design. The sawmill was assumed to operate 229 days annually on average.

The direct labour input was estimated to be 3.8 man-hours/m^3 sawn based on the one-shift operation and 3.6 man-hours based on two-shifts, using data collected by the author for comparable sawmills in the southern United States and for sawmills in Australia and New Zealand. An estimated 1.0 and 2.35 man-hours per m^3 sawn is incorporated in each of these figures respectively for shift work.

Labour overheads were estimated to amount to 20 percent of direct labour costs and include worker's compensation insurance (currently fixed at a maximum of 15.11 percent of wages in New South Wales), long service leave and super-annuation and payroll tax.

Maintenance costs, other than wages, were estimated to be 50 percent of those for depreciation for a one-shift operation and 90 percent for a two-shift operation.

Supplies which includes all material other than sawlogs, and fuel, and power and fuel were estimated to cost \$2.1 and \$2.5 per m^3 sawn respectively. Both costs were based on unpublished confidential data supplied to the author and were considered to be satisfactory by othe r experienced industry representatives.

The average total costs of production of \$34.21 per m^3 sawn for one-shift operations and of \$29.24 per m^3 sawn for two-shift operations shown in Table 6.1.6, appear to be considerably higher than those experienced by comparable overseas sawmills as can be seen in Table 6.1.7 in which the costs for several United States sawmills are presented.

TABLE 6.1.7

Comparison of average costs of production for five United States' sawmills with those for the hypothetical radiata pine sawmill adopted in this study.

Sawmill Description	Production per shift (m^3)	Number of shifts per day	Average cost per m^3 (1972/73$A)
Southern pine sawmills:-			
Chipping heading and double bandmill (Reilly 1971)	400	2	19.47
Conventional bandmill (Reilly 1971)	280	2	22.18
Conventional circular mill (Taylor and Garton, 1970)	118	1	23.29
Douglas fir sawmills (Mead, 1966):-			
Mill A	225	1 2	26.65 19.04
Mill B	290	1 2	28.29 22.64
Hypothetical sawmill (McEwan 1974)	390	2	22.68
Hypothetical radiata pine sawmill in this study	220	1 2	34.21 29.24

DERIVATION OF VALUE OF SAWMILL CHIPS

The first part of the equation (6.2) in parenthesis represents the value of the chips at the sawmill per cubic metre solid volume of chips; the remainder of the equation, (0.90 - Ri) converts the first part of the equation into the value of chips recovered from a sawlog of size-class i per m^3 of sawntimber. The value, 0.90, defines the maximum volume that can be recovered as either sawntimber or chips from each cubic metre of sawlogs. This is 7 percent higher than the 83 percent reported to be recovered from a conventional southern pine sawmill in the United States over a full year's operations (Williams and Hopkins, 1968.) but was based on the higher recovery that could be anticipated from a mill using modern technology, in particular narrow kerf band saws, where sawdust production would be considerably less.

The F.O.B. price of chips at Edrom (P) was assumed to be identical to the F.O.B. price of \$27.00/BDMT adopted for export chips in the previous chapter. A basic density, B, of 448 kg/m^3 was adopted, and was considered to be slightly lower than the basic density of new growth wood produced in trees 20 years and older (Shepherd, personal communication).

Because suitable data were unavailable, the aggregate cost of chip-piling and conveyorisation (X) and chipping (G) was assumed to be equal to the cost of \$2.95/m^3 estimated in the previous chapter for yarding, chipping and conveyorisation.

A haulage cost of 3 cents/m^3/km was adopted, based on data reported by Ironside and Krilov (1973). Unloading and turnaround costs amounting to \$0.20/m^3 were also incorporated and a highway standard road was assumed to connect each of the hypothetical sawmills to Edrom.

The value of the chips in the hopper at each sawmill was estimated to be \$5.95/m^3 solid volume, each sawmill being located approximately 100 km from Edrom. Therefore the values of the chips per m^3 of sawntimber for each tree shown on Table 7.5 apply to both sawmills.

APPENDIX 6.2

PRICES FOR UNPRUNED SAWLOGS BASED ON THE COST OF IMPORTED DOUGLAS FIR FRAMING FROM THE UNITED STATES (1972/73 $A PER M^3)

Management Area	Less than 30 cm	30 to 35 cm	35 to 40 cm	40 to 50 cm	50 plus cm
Bega Sawmill - One shift per day basis (Prior to year 2005/6)					
Bega	12.44	15.26	19.16	20.13	20.81
Bemboka	11.43	14.25	18.15	19.12	19.80
Burragate	10.10	12.92	16.82	17.79	18.47
Candelo	12.07	14.89	18.79	19.76	20.44
Cobargo	11.18	14.00	17.90	18.87	19.55
Lower Brogo	12.08	14.90	18.80	19.77	20.45
Pambula & Wyndham	10.98	13.80	17.70	18.67	19.35
Bega Sawmill - Two shifts per day basis (Year 2005/6 +)					
Bega	14.42	17.50	21.64	22.76	23.55
Bemboka	13.41	16.49	20.63	21.75	22.54
Burragate	12.08	15.16	19.30	20.42	21.21
Candelo	14.05	17.13	21.27	22.39	23.18
Cobargo	13.16	16.24	20.38	21.50	22.29
Lower Brogo	14.06	17.14	21.28	22.40	23.19
Pambula & Wyndham	12.96	16.04	20.18	21.30	22.09
Bombala Sawmill - One shift per day basis (Prior to year 2005/6)					
Bondi	11.59	14.37	18.23	19.18	19.84
Nungatta	10.59	13.37	17.23	18.18	18.84
Bombala Sawmill - Two shifts per day basis (Year 2005/6 +)					
Bondi	13.57	16.61	20.71	21.81	22.58
Nungatta	12.57	15.61	19.71	20.81	21.58

APPENDIX 6.3

SAWLOG PRICES BASED ON THE EXPORT PRICE OF SAWLOGS

FROM NEW ZEALAND ($ per m^3)

Management Area	D.B.H. (cm)				
	Less than 30 cm	30 to 35 cm	35 to 40 cm	40 to 50 cm	50 + cm
Bega Sawmill					
Bega	3.58	5.01	6.25	6.80	7.19
Bemboka	2.78	4.21	5.45	5.95	6.39
Burragate	5.18	6.61	7.85	8.40	8.79
Candelo	3.78	5.21	6.45	7.00	7.39
Cobargo	1.98	3.41	4.65	5.20	5.59
Lower Brogo	2.58	4.01	5.25	5.80	6.19
Pambula	5.34	6.77	8.01	8.56	8.95
Wyndham	4.38	5.81	7.05	7.60	7.99
Bombala Sawmill					
Bondi	4.86	6.29	7.53	8.08	8.47
Nungatta	5.18	6.61	7.85	8.40	8.79

APPENDIX 6.4

UPPER LIMIT OF UPPER BOUND STUMPAGE PRICES FOR

RADIATA PINE OF DIFFERENT SIZES ($\$/M^3$)

Management Area	d.b.h. (cm)				
	Less than 30	30 to 34.9	35 to 39.9	40 to 49.9	50 +
Bega Sawmill - One shift per day operation (Prior to year 2005/6)					
Bega	15.19	18.63	23.39	24.57	25.40
Bemboka	13.95	17.40	22.16	23.34	24.17
Burragate	12.33	15.77	20.53	21.72	22.55
Candelo	14.73	18.08	22.94	24.12	24.95
Cobargo	13.65	17.09	21.85	23.04	23.87
Lower Brogo	14.75	18.19	22.95	24.14	24.97
Pambula & Wyndham	13.40	16.85	21.61	22.79	23.62
Begal Sawmill - Two shift per day operation (Year 2005/6 +)					
Bega	17.60	21.36	26.42	27.79	28.75
Bemboka	16.37	20.13	25.18	26.55	27.52
Burragate	14.75	18.51	23.56	24.93	25.89
Candelo	17.15	20.91	25.97	27.33	28.30
Cobargo	16.07	19.83	24.88	26.25	27.21
Lower Brogo	17.16	20.92	25.98	27.35	28.31
Pambula & Wyndham	15.82	19.58	24.64	26.00	26.97
Bombala Sawmill - One shift per day operation (Prior to year 2005/6)					
Bondi	14.15	17.54	22.26	23.41	24.22
Nungatta	12.93	16.32	21.03	22.19	23.00
Bombala Sawmill - Two shifts per day operations (Year 2005/6 +)					
Bondi	16.59	20.28	25.28	26.63	27.56
Nungatta	15.35	19.06	24.06	25.40	26.34

APPENDIX 9.1

THE LINEAR PROGRAMMING MATRIX GENERATOR - LPGEN

This was based on a paper entitled "A Linear Programming Matrix Generator for Forest Planning Models" by J. A. Miles, I. S. Ferguson and J. J. Reilly.

The paper was presented at a Workshop arranged by Research Working Group 2 of the Australian Forestry Council, Mensuration and Management, on "Recent Developments in Forest Models" and held in Melbourne from 6 - 7 December 1976.

ABSTRACT

This paper describes a computer programme developed to facilitate entry and computation of data, and preparation of the coefficient matrix, for a linear programming model being used to investigate forest management strategies in the lower South Coast Region of New South Wales.

The programme has been developed within a general framework which lends itself to application to similar problem with only minor modification.

2. GENERAL SPECIFICATIONS

2.1. Data tables are created for use in subsequent computations. A series of specifications has been defined to control the creation of these tables.

2.2. (a) The basis unit of specification is the problem , which consists of statements.

(b) A statement consists of reserved words and data items.

(c) Reserved words are the labels which define the tables and the data items are a collection of attributes to be stored in the table concerned. Attributes include identifiers and/or data values.

2.3. All input is in card input and free format subject to the following rules:-

(a) A statement must commence on a new card. It may be continued on as many cards as desired, provided they contain a continuation symbol in column 1.

(b) The character set for statements consists of all punchable characters except the following, which have specific roles:

(i)	# (in column 1)	-	continuation symbol
(ii)	< >	-	comment delimiters
(iii)	:	-	data item separator
(iv)	,	-	attribute separator
(v)	a blank (hereafter shown ‸)	-	delimits any character string

Note that embedded blanks are not permitted. Only the first 12 characters of any identifier are considered, the remainder are truncated.

2.4 All values may be entered as optionally signed integer or real numbers. If the program requires a real value and an integer is entered, automatic conversion will take place. Similarly integer values will be truncated to real values where necessary. FORTRAN exponential notation is not permitted.

2.5 (a) Spaces (blanks) may be inserted anywhere between reserved words, between a reserved word and an attribute, or between attributes. Embedded blanks cannot be used.

(b) Embedded comments denoted by < comment string > may be inserted between reserved words, between a reserved word and an attribute, or between identifiers and/or data values.

2.6 The set of reserved words comprises:

INTEREST

ROTATION

TERMVAL

JOB

NEWJOB

COMMENT

SET {X}

RESET {X}

where {X} is one of the set

ANNUAL

SINGLE

PERIODIC

YIELD

PRICES

LIMITS

2.7 The general format of a statement is

{reserved word} ‸ {data item} : {data item} :

where {data item} ≛ {identifier} {data value}, {data value}

Note that an attribute may consist of an null character string.

2.8 The effect of a statement is to clear the appropriate table of all identifiers and entries and to assign the new identifiers and data values to the table.

2.9. The one exception to this rule is the RESET {X} type of statement. Here only the data values are cleared and replaced, the identifiers remain unchanged. Thus the RESET {X} type statement cannot contain an identifier.

3. DATA INPUT

3.1. Based on the specifications defined in the previous section, data can be entered into the appropriate table. Further details and examples of data input follow.

3.2. Interest rates

One table is used to store the interest rates to be used in the subsequent analysis. Up to 10 values may be supplied, but they must be expressed as percentages.

```
e.g.    INTEREST ^ 5.0, 6, 7
or      INTEREST ^ 5, ^ 6, 7
or      INTEREST ^ 5: 6: 7
```

sets up 3 interest rates of 5.0, 6.0 and 7.0 percent.

3.3. Investment horizon

One table (labelled ROTATION) is used to store rotation lengths, cutting cycles, or whatever number of years is appropriate to the total period covered by the investment analysis. Up to 10 periods may be entered

e.g. ROTATION ‸ 60.1, 70.0, 80

or ROTATION ^ 60 : 70 : 80

sets up periods of 60, 70 and 80 years.

3.4. Terminal value

One table (TERMVAL) is used to store the terminal or scrap value of the investment at the end of the investment horizon

e.g. TERMVAL ‸ 2000.0

sets up a terminal value of $2000.

3.5. Costs

There are three classes of costs. Each uses a statement prefixed by SET and followed by the appropriate label {X}, identifier, and data values

(a) Single payments are costs which occur in one specific year of the investment horizon. The statement has the format

SET ‸ SINGLE ‸ {identifier} ‸ {value of cost} , {time of occurrence} : {identifier} value...etc.

Up to 30 sets of single payments may be entered from this statement.

e.g. SET ‸ SINGLE ‸ COST1 ‸100.00, 10 : COST2 ‸200., 15:

sets up two single payments of $100 and $200 occurring 10 and 15 years from the base year with identifiers COST 1 and COST 2.

(b) Periodic payments are costs occurring at regular intervals. Provision is also made for specifying the annual rate of change for the value concerned beyond the commencement year. The statement has the format

SET ‸ PERIODIC ‸ {identifier} ‸ $\{v_1\}$, $\{a_1\}$, {t} , $\{a_2\}$, {g} :

where v_1 denotes the value of the cost at

a_1 the commencement year (default = 1)

t denotes the interval between payment (default = 1)

a_2 denotes the termination year (default = investment horizon)

g denotes the annual rate of growth in v_1 (default = 0%)

e.g. SET ‸ PERIODIC ‸ RATES 1 50.0, 10, 2 :

sets up a periodic payment of $50.00 made first 10 years from the base year and every 2 years thereafter to the investment horizon. The annual rate of growth would be zero

e.g. SET ‸ PERIODIC ‸ RATES 2 ‸ 50.0, , 2 :

Here the two adjacent delimiters ensure that the third attribute {t} is an empty string. The period between payments would therefore default to 1 year.

(c) Annual payments are those occurring every year. The specifications are otherwise similar to those for periodic payments:-

SET ‸ ANNUAL ‸ {identifier} $\{v_1\}$, $\{a_1\}$, $\{a_2\}$, { g}

Note that revenues can be treated as negative costs if they cannot be otherwise conveniently entered.

3.6. Revenues

Revenues are computed from data entered into three separate tables.

(a) Yields are the physical outputs (volumes) of particular products. The yield statement has the format:

SET ‸ YIELD ‸ {id} $\{a_y\}$, $\{q_1\}$, $\{q_2\}$: {identifier} etc.

where $\{a_y\}$ denotes the year beyond the base year in which the yield is harvested and sold (default = 0)

$\{q_1\}$ denotes the quantity produced if $\{a_y\}$ < investment horizon (default = 0)

$\{q_2\}$ denotes the quantity produced if $\{a_y\}$ = investment horizon (default = 0)

Note that this statement can be used to set up both thinning and final - crop yields at a given age for even - aged regimes.
Alternatively, it can be used to set up periodic yields from uneven - aged regimes. Only the former will be illustrated :

```
SET ^ YIELD ^ PROD1  ^ 50,  100.0 , 200 : PROD2  ^ 60, 110, 220 :
#             PROD3  ^ 70,  2 , 250 : PROD4 ^ 75 , 250 :
```

This statement sets up the following yields

Product identifier	Age	Thinning yield	Final crop yield
PROD 1	50	100	200
PROD 2	60	110	220
PROD 3	70	0	250
PROD 4	75	200	0

Thus if the strategy involves a thinning at age 50 years, the yield of PROD 1 is 100 units. If it involves clear-felling at age 50 years, the yield of PROD 1 is 200 units.
The program tests the value of age against the value specified for the investment horizon (rotation length) to determine whether a thinning or a clear-felling is required.

(b) Prices are the revenues reserved per unit of product yield. The price statement has the format

```
SET ^ PRICE ^ {id} ^ {value of price} , {g_p} : etc.
```

The default value of price is zero, as is the default value for the annual rate of growth (g_p) of price.

3.7. Coefficient matrix

The definition of the structure of the coefficient matrix for the linear programming model requires a special specification statement. Although FMPS allows row identifiers to comprise up to eight characters, the last two characters must be reserved in this type of model for the identification of the planning period. Thus six character identifiers are used during input in this program, longer identifiers being automatically truncated to six characters. The basic format of the statement is as follows:

SET ‸ LIMITS ‸ {id 1} ‸ {= ‸ id 2} ‸ {= ‸ id 3} ‸ {a} , {b} :

where {id 1} denotes the identifier used to search the data tables

{id 2} and {id 3} denote other identifiers assigned to the values found for id 1 when preparing the coefficient matrix , a is an index denoting the data table to be searched for the values:

{a} = 0 : assign the value of a to id 1

{a} = -1 : search SINGLE and PERIODIC payments tables to locate the value

{a} = -2 : search YIELD table to generate the value

{a} = -3 : assign the value of the area coefficient in the NEWJOB table to id 1.

b is a switch used to control the addition of the planning period identification to the row name identifier (default value = 0)

{b} 0 : number of planning period is used

{b}≠ 0 : number of planning period is not used.

e.g. SET ‸ LIMITS ‸ LOAN = LOANBM = LOANS ‸ -1 :

The statement caused rows with the names LOAN, LOANBM and LOANS to be generated. The identifier LOAN is used to search the SINGLE and PERIODIC payment tables. The coefficient in all three resultant rows will have the same values. The switch is set to add the number of the planning period commenced to the row identifier.

4. DECK STRUCTURE AND PROCESSING

4.1 Processing control is effected through the use of additional statements which will be outlined in later sections. Each new problem constitutes a set of related investment analyses. The card deck of a new problem would normally commence with a comment card which indicates the management unit and type of strategy to be examined. The statement takes the format:

COMMENT ^ {character string}

This character string is reproduced during the edit output of the program.

4.2 Statements specifying investment horizons, interest rates, costs, revenues and limits (optional) are inserted after the comment card but may be arranged in any order.

4.3 After the basic data tables have been specified for the first problem, processing is initiated by a special statement having the format:-

NEWJOB ^ {id} , {pp} , {area} :

where {id} denotes an identifier for the management unit and type of strategy

{pp} denotes the serial number of the last planning period in the LP model (default = 9) {area} denotes the coefficient value for all the area constraints in the problem (default = 1.0)

The specification of the last planning period enables the linear programming planning horizon to be varied from the 50 year period used in the South Coast study. The length of the planning period in the South Coast study (5 years) cannot be modified, although this would involve only minor changes to the program.

4.4. The preceeding specifications cater for the analysis of present net worth and related coefficients for the linear programming model up to the investment horizon. Suppose this has been set for a rotation of thirty years. Further specifications are required to extend the analysis of present net worth to an infinite horizon and to calculate the remaining coefficient from thirty years to the end of the linear programming horizon (50 years for the South Coast study). These specifications take the form

RESET {x} data items as per {x}

where {x} is a specification statement such as COST, YIELD etc.

Details of the proceedure here are somewhat specific to the approach used in the South Coast study but the program can readily be modified to other bases.

4.5 Where, as in the South Coast study, a set of different present net worth values are to be calculated based on differing prices or costs at different points in time, they are processed by following the appropriate RESET statement with the specification :

JOB

This specification initiates the particular net worth calculation.

4.6 Once all present net worths have been specified, a new problem may be entered by commencing a new set of COMMENT and other specification. If a particular specification is not re-entered (e.g. INTEREST), the data table from the previous problem is used.

4.7 A listing of a sample deck is shown in Figure 1 to illustrate the typical structure of a deck. This data deck was processed using the program and Figure 2 shows the resultant listing of the computed data. A printout of this coefficient matrix prepared for input into FMPS is shown in Figure 3.

5. ERROR HANDLING

5.1 The program operates in two passes. In the first pass, the syntax is checked and data tables are constructed; the tables being coded in an internal format. In the second pass, the present net worth and related computations are carried out and the linear programming matrix is created for subsequent use in FMPS. The second pass involves the use of far more computer time and resources. Thus the program is aborted after the first pass if errors have been found.

5.2 The following classes of errors are checked and identified:

(i) A statement commencing with other than a reserved symbol

(ii) An unknown symbol occurring in a position where a reserved symbol is expected.

(iii) Numerical values which are incorrectly coded.

(iv) The number of attributes exceeding the number permitted for the data item.

(v) A card without at least one data item.

(vi) Price data which are inconsistent with yield data in every product must have only one defined price.

(vii) Duplication of price identifiers.

5.3 When an error is identified, the offending statement is listed along with its line number in the data deck. All valid data are extracted from the statement. Processing then continues on the next statement. The total number of errors is printed out at the end of the pass.

5.4 Although most errors are identified in the first pass, some further checks are made in the second pass to identify:-

(i) Illegal options in SET LIMITS statements

(ii) Identifiers which are nominated in the SET LIMITS statement but are missing from the data table concerned.

Appropriate warning messages are printed out for these conditions, but processing is not aborted since they may be valid options.

5.5 The program also carries out some internal checking of its own operations. Appropriate messages and diagnostic tables are printed out if this occurs, and the program is aborted.

6. DISCUSSION

6.1 The program is still in the early stages of development. It has been used to produce larger coefficient matrices which have subsequently been solved using FMPS.

6.2 Further developments are underway to facilitate the linkage of stand simulation packages into the general framework. It is also hoped to generalize and simplify the existing sections dealing with the computation of present net worth in the South Coast Study.

*** INPUT DATA ***

```
COMMENT   BONDI CROWN                       FORESTRY  A
ROTATION  15 20
INTEREST  5.0
SET ANNUAL RINV 7.0:CRF 3.5:
SET SINGLE LOAN 516.5,0:CRF 104.6,0:RINV 20.0,0:LOAN 16.3,1:CRF 3.0,1:
SET PRICE PULPEC 1.85:QSAWBM 6.72:PULPRF 0.77:PULPRF1 4.61:
SET YIELD PULPEC 0,100:QSAWBM 0,15:PULPRF 15,,284:PULPRF1 20,,475:
SET LIMITS LOAN = LOANBM -1:PULPEC = DPULP = HPULPT -2:QSAWBM = DSAW -2:
# PULPRF = DPULP -2:PULPRF1 = DPULP -2: PLANTB 1.0:
NEWJOB BIMBA 3:
RESET PRICE 0:0:4.61:4.61:
JOB
RESET SINGLE 360.4,0:66.0,0:0,0:16.3,1:3.0,1:
RESET YIELD 0: 0: 15,,284: 20,,475:
JOB
COMMENT   COOLANGUBRA                       FORESTRY  A
SET SINGLE LOAN 516.5,0:CRF 104.6,0:RINV 20.0,0:LOAN 16.3,1:CRF 3.0,1:
SET PRICE PULPEC 1.46:QSAWBM 7.28:PULPRF 0.39:PULPRF1 4.23:
SET YIELD PULPEC 0, 91:QSAWBM 0,14:PULPRF 15,,284:PULPRF1 20,,475:
NEWJOB COMBA 3:
RESET PRICE 0:0:4.23:4.23:
JOB
RESET SINGLE 360.4,0:66.0,0:0,0:16.3,1:3.0,1:
RESET YIELD 0: 0: 15,,284: 20,,475:
JOB
ROTATION 30 40 50
SET ANNUAL RINV 0.9:CRF 0.45:
SET SINGLE LOAN 67.4,0:CRF 12.3,0:
SET PRICE PULPEP 0.62:DSAW  8.04:PULPEP1 1.02:
SET YIELD PULPEP 0, 84:DSAW 0, 8:PULPEP1 30,,66:PULPEP1 40,,134:PULPEP1
#50,,188:
SET LIMITS LOAN1 -1:PULPEP = DPULP -2:DSAW -2:PULPEP1 = DPULP -2:
NEWJOB BEMDN
RESET PRICE 0.62:9.05:1.02:
JOB
RESET SINGLE 48.6,0: 8.8,0:
RESET YIELD 0:0:30,,66:40,,134:50,,188:
JOB
```

Fig 1

```
¤ROTATION¤ CARD PROCESSED..... VALUES FOLLOW
   ROTATION LENGTHS ARE     15 YEARS      20 YEARS

¤INTEREST¤ CARD PROCESSED..... VALUES FOLLOW
   INTEREST RATES ARE    5.0%

SET ANNUAL VALUES CARD PROCESSED.. VALUES FOLLOW
   RINV                            7.00         1.0           .0      .000
   CRF                             3.50         1.0           .0      .000

SET SINGLE VALUES CARD PROCESSED.. VALUES FOLLOW
   LOAN                          516.500         .0
   CRF                           104.600         .0
   RINV                           20.000         .0
   LOAN                           16.300        1.0
   CRF                             3.000        1.0

SET ¤PRICES¤ CARD PROCESSED.... VALUES FOLLOW
   PULPEC                          1.85          .00
   QSAWBM                          6.72          .00
   PULPRF                           .77          .00
   PULPRF1                         4.61          .00

SET YIELD VALUES CARD PROCESSED.... VALUES FOLLOW
   PULPEC                            .0       100.00         .00
   QSAWBM                            .0        15.00         .00
   PULPRF                          15.0          .00      284.00
   PULPRF1                         20.0          .00      475.00

SET ¤LIMITS¤ VALUES CARD PROCESSED.. VALUES FOLLOW
   LOAN                           -1.00          .0
   LOANBM                    EQUIVALENT  TO :LOAN
   PULPEC                         -2.00          .0
   DPULP                     EQUIVALENT  TO :PULPEC
   HPULPT                    EQUIVALENT  TO :PULPEC
   QSAWBM                         -2.00          .0
   DSAW                      EQUIVALENT  TO :QSAWBM
   PULPRF                         -2.00          .0
   DPULP                     EQUIVALENT  TO :PULPRF
   PULPRF1                        -2.00          .0
   DPULP                     EQUIVALENT  TO :PULPRF1
   PLANTB                          1.00          .0

NEWJOB  CARD PROCESSED..... JOBNAME = **BIMBA      JOB AREA = 1.0      LAST MANAGEMENT PERIOD = 3.

RESET PRICE VALUES CARD PROCESSED.... VALUES FOLLOW
   PULPEC                           .00          .00
   QSAWBM                           .00          .00
   PULPRF                          4.61          .00
   PULPRF1                         4.61          .00

JOB CARD PROCESSED.... CURRENT JOBNAME = **BIMBA      JOB AREA = 1.0      LAST MANAGEMENT PERIOD = 3.

RESET SINGLE VALUES CARD PROCESSED.. VALUES FOLLOW
   LOAN                          360.400         .0
   CRF                            66.000         .0
   RINV                             .000         .0
```

Fig 2 - 1

JOB AREA = 1.0 LAST MANAGEMENT PERIOD = 3

OWN FORESTRY A

= 2 INTEREST RATE = 5.0% NUMBER OF PLANNING PERIODS = 3

ESENT NET WORTHS

-377.48	-138.70	76.00
320.76	34.96	249.66

LEV VALUES

-307.04	-240.57	-188.50	-147.69	-25.73	-20.16	-15.79	-12.37	-9.70	-7.60
471.77	369.64	289.62	226.93	70.09	54.92	43.03	33.71	26.42	20.70

JOB AREA = 1.0 LAST MANAGEMENT PERIOD = 3

RA FORESTRY A

2 INTEREST RATE = 5.0% NUMBER OF PLANNING PERIODS = 3

SENT NET WORTHS

-480.41	-190.61	24.09
201.71	-33.07	181.63

LEV VALUES

458.08	-358.92	-281.22	-220.35	-63.43	-49.70	-38.94	-30.51	-23.90	-18.73
311.57	244.12	191.28	149.87	28.94	22.68	17.77	13.92	10.91	8.55

Fig 2 - 2

1:	B1MBA150	LEV		-307.0387	B1MB		1.000000
2:	B1MBA150	LOAN	0	532.8000	LOANBM	0	532.8000
3:	B1MBA150	PULPEC	0	100.0000	DPULP	0	100.0000
4:	B1MBA150	HPULPT	0	100.0000	QSAWBM	0	15.00000
5:	B1MBA150	DSAW	0	15.00000	PLANTB	0	1.000000
6:	B1MBA150	LOAN	3	376.7000	LOANBM	3	376.7000
7:	B1MBA150	PULPRF	3	284.0000	DPULP	3	284.0000
8:	B1MBA150	LOAN	6	376.7000	LOANBM	6	376.7000
9:	B1MBA150	PULPRF	6	284.0000	DPULP	6	284.0000
10:	B1MBA150	LOAN	9	376.7000	LOANBM	9	376.7000
11:	B1MBA150	PULPRF	9	284.0000	DPULP	9	284.0000
12:	B1MBA151	LEV		-240.5728	B1MB		1.000000
13:	B1MBA151	LOAN	1	532.8000	LOANBM	1	532.8000
14:	B1MBA151	PULPEC	1	100.0000	DPULP	1	100.0000
15:	B1MBA151	HPULPT	1	100.0000	QSAWBM	1	15.00000
16:	B1MBA151	DSAW	1	15.00000	PLANTB	1	1.000000
17:	B1MBA151	LOAN	4	376.7000	LOANBM	4	376.7000
18:	B1MBA151	PULPRF	4	284.0000	DPULP	4	284.0000
19:	B1MBA151	LOAN	7	376.7000	LOANBM	7	376.7000
20:	B1MBA151	PULPRF	7	284.0000	DPULP	7	284.0000
21:	B1MBA152	LEV		-188.4951	B1MB		1.000000
22:	B1MBA152	LOAN	2	532.8000	LOANBM	2	532.8000
23:	B1MBA152	PULPEC	2	100.0000	DPULP	2	100.0000
24:	B1MBA152	HPULPT	2	100.0000	QSAWBM	2	15.00000
25:	B1MBA152	DSAW	2	15.00000	PLANTB	2	1.000000
26:	B1MBA152	LOAN	5	376.7000	LOANBM	5	376.7000
27:	B1MBA152	PULPRF	5	284.0000	DPULP	5	284.0000
28:	B1MBA152	LOAN	8	376.7000	LOANBM	8	376.7000
29:	B1MBA152	PULPRF	8	284.0000	DPULP	8	284.0000
30:	B1MBA153	LEV		-147.6908	B1MB		1.000000
31:	B1MBA153	LOAN	3	532.8000	LOANBM	3	532.8000
32:	B1MBA153	PULPEC	3	100.0000	DPULP	3	100.0000
33:	B1MBA153	HPULPT	3	100.0000	QSAWBM	3	15.00000
34:	B1MBA153	DSAW	3	15.00000	PLANTB	3	1.000000
35:	B1MBA153	LOAN	6	376.7000	LOANBM	6	376.7000
36:	B1MBA153	PULPRF	6	284.0000	DPULP	6	284.0000
37:	B1MBA153	LOAN	9	376.7000	LOANBM	9	376.7000
38:	B1MBA153	PULPRF	9	284.0000	DPULP	9	284.0000
39:	B1MBA200	LEV		471.7668	B1MB		1.000000
40:	B1MBA200	LOAN	0	532.8000	LOANBM	0	532.8000
41:	B1MBA200	PULPEC	0	100.0000	DPULP	0	100.0000
42:	B1MBA200	HPULPT	0	100.0000	QSAWBM	0	15.00000
43:	B1MBA200	DSAW	0	15.00000	PLANTB	0	1.000000
44:	B1MBA200	LOAN	4	376.7000	LOANBM	4	376.7000
45:	B1MBA200	PULPRF	4	475.0000	DPULP	4	475.0000
46:	B1MBA200	LOAN	8	376.7000	LOANBM	8	376.7000
47:	B1MBA200	PULPRF	8	475.0000	DPULP	8	475.0000
48:	B1MBA201	LEV		369.6416	B1MB		1.000000
49:	B1MBA201	LOAN	1	532.8000	LOANBM	1	532.8000
50:	B1MBA201	PULPEC	1	100.0000	DPULP	1	100.0000
51:	B1MBA201	HPULPT	1	100.0000	QSAWBM	1	15.00000
52:	B1MBA201	DSAW	1	15.00000	PLANTB	1	1.000000
53:	B1MBA201	LOAN	5	376.7000	LOANBM	5	376.7000
54:	B1MBA201	PULPRF	5	475.0000	DPULP	5	475.0000
55:	B1MBA201	LOAN	9	376.7000	LOANBM	9	376.7000
56:	B1MBA201	PULPRF	9	475.0000	DPULP	9	475.0000
57:	B1MBA202	LEV		289.6239	B1MB		1.000000
58:	B1MBA202	LOAN	2	532.8000	LOANBM	2	532.8000
59:	B1MBA202	PULPEC	2	100.0000	DPULP	2	100.0000
60:	B1MBA202	HPULPT	2	100.0000	QSAWBM	2	15.00000
61:	B1MBA202	DSAW	2	15.00000	PLANTB	2	1.000000
62:	B1MBA202	LOAN	6	376.7000	LOANBM	6	376.7000
63:	B1MBA202	PULPRF	6	475.0000	DPULP	6	475.0000
64:	B1MBA203	LEV		226.9279	B1MB		1.000000
65:	B1MBA203	LOAN	3	532.8000	LOANBM	3	532.8000
66:	B1MBA203	PULPEC	3	100.0000	DPULP	3	100.0000
67:	B1MBA203	HPULPT	3	100.0000	QSAWBM	3	15.00000
68:	B1MBA203	DSAW	3	15.00000	PLANTB	3	1.000000

Fig 3

APPENDIX 10.1

GROSS AREAS BY MANAGEMENT AREAS AND LAND TENURES

AS AT 1 JANUARY 1973

Management Area	Gross Area (ha)	State Forests & Timber Reserves	Vacant Crown Land	Other Crown Land	Private Property	Cleared
Pulpwood Zone - Predominantly Crown Lands						
Bondi C & P	22,850	18,810	-	-	4,040	1,920
Coolangubra	8,550	8,550	-	-	-	-
East Boyd	23,350	22,450	-	-	900	-
Glenbog	18,400	18,000	200	-	200	300
Naghi	37,300	35,230	-	-	2,070	150
Nullica-Bimmil	16,750	10,000	6,750	-	-	-
Tantawanglo	18,630	17,280	-	-	1,350	570
Towamba	22,600	22,200	-	-	400	-
White Rock	9,460	9,260	-	-	200	-
Yambulla North	28,240	28,240	-	-	-	-
Yambulla South	28,400	28,400	-	-	-	-
Yurammie - Burragate	23,320	11,880	11,140	-	300	-

Management Area	Gross Area (ha)	State Forests & Timber Reserves	Vacant Crown Land	Other Crown Land	Private Property	Cleared
Pulpwood Zone - Predominantly Private Property						
Bega	27,970	-	200	-	27,770	25,900
Bemboka	25,510	-	200	-	25,310	21,070
Burragate	15,950	-	600	-	15,350	7,670
Candelo	29,840	-	300	-	29,540	25,400
Lower Towamba	3,170	-	310	-	2,860	1,140
Nungatta	8,180	-	-	-	8,180	4,850
Pambula	14,550	-	1,700	-	12,850	7,040
Wallagoot	17,000	-	400	8,650	7,950	2,570
Wyndham	16,270	-	200	-	16,070	7,360
Transition Zone - Predominantly Crown Lands						
Brown Mountain	20,230	-	18,470	-	1,760	-
Mumbulla C & P	24,760	12,020	5,280	-	7,460	2,280
Murrah C & P	20,500	13,753	350	600	5,799	1,600
Transition Zone - Predominantly Private Property						
Cobargo	28,390	-	-	-	28,390	21,030
Lower Brogo	16,990	-	-	-	16,990	10,880

C - Crown Lands

P - Private Property

Management Area	Gross Area (ha)	State Forests & Timber Reserves	Vacant Crown Land	Other Crown Land	Private Property	Cleared
<u>Mining Timber Zone</u>						
Belimbla	18,860	9,010	9,540	-	310	-
Bodalla C & P	43,000	19,700	2,300	600	20,400	8,800
Currowan C & P	19,670	17,225	195	-	2,250	-
Mogo C & P	34,430	17,635	1,415	-	15,380	4,560
Moruya C & P	41,520	15,960	10,190	-	15,370	8,810
Nerrigundah	24,570	9,010	11,090	-	4,470	1,350
North Kioloa C & P	37,600	23,110	2,000		12,490	4,560
Quartpot C &P	15,740	2,450	8,090	-	5,200	2,600
South Kioloa C & P	27,450	19,640	1,350	-	6,460	2,070
Tinpot C & P	20,510	17,920	520	-	2,070	-
Wadbillaga	14,190	-	13,680	-	510	-
<u>Sawlog Zone</u>						
Araluen C & P	39,680	1,700	7,360	-	30,620	13,000
Badja	14,750	14,600	-	-	150	-
Belowra C & P	21,240	-	15,000	-	6,240	1,970
Buckenbowra C &P	21,250	-	18,210	-	3,040	620
Burra Creek C & P	43,510	-	39,060	-	4,450	-
Deau	29,470	-	26,000	-	3,470	-
Murrabrine	7,610	3,860	3,250	-	500	-
Upper Brogo	31,120	-	31,000	-	120	-
Upper Turross C & P	22,070	-	6,320	-	15,750	9,320
Yadboro	36,260	11,575	24,685	-	-	-
Yourie	15,640	-	15,120	-	520	-

APPENDIX 10.2

INVENTORIES UNDERTAKEN IN THE INDIGENOUS FORESTS OF THE LOWER SOUTH COAST

Following Carron's (1968) classification of forest inventories, six broad categories were defined. Forest resource inventories were designed to assess the resource both qualitatively and quantitatively as an integral part of State-wide surveys, whereas management surveys were designed to achieve some specific objective of management.

A. Forest Resource Inventories

1. Forest Resource Classification of 1950's

This inventory was restricted to the eastern part of New South Wales and was designed to provide a classification of forest land into its potential for timber production and protection. In all, seven classes of forest land were identified. The inventory was carried out on a County by County basis and involved identifying the dominant forest types and describing the composition of the forest in terms of stand type (sapling, pole, pile or mill-log) and percentage crown cover. These surveys were of limited use but assisted in identifying Management Units in individual Management Areas.

2. FORWOOD Resource Inventory

The FORWOOD inventory of forest resources covered the whole State with sampling intensity greater on the eastern part of the State where a 2,745 metre grid was used, each point representing 752.5 ha. The survey was carried out in two stages; the first, involving map preparation and the evaluation of parameters that could be interpreted direct from maps; and the second stage consisted of the evaluation of the following stand parameters by means of aerial photos:-

(i) Vegetation structure
(ii) Species types
(iii) Volume classes
(iv) Dominant diameter class and
(v) Slope classes

The A.P.I. data were supplemented with relevant information from other inventories and the combined data were analyzed by computer to provide results in both tabular and map form. Again this survey's usefulness was limited although it proved to be more satisfactory than the old forest resources surveys particularly in those areas not covered by more detailed surveys.

B. Forest Management Inventories

1. Continuous Forest Inventory with Management Plan

The Bodalla Management Group (Hynd 1962) consisting of State Forests in Bodalla Management Area was the only part of the Region covered by a management plan based on data from permanently established plots. This inventory comprising 214 circular plots of approximately 0.1 hectare in area, systematically located on a 915 metre grid was initiated in 1960. The estimated prescribed yield of quota sawlogs was 3,906 m^3 per annum to be supplied to sawmills with entitlements to Crown timber.

2. Management Assessment Survey with Management Plan

Again only one area, the Kioloa Management Group (Crowe 1967), was involved. It included all State Forests east of the Clyde River between Ulladulla and Bateman's Bay in North and South Kioloa Management Areas.

Just over 38,300 hectares were involved and consisted of 119 randomly located temporary rectangular plots of approximately 0.61 hectares.

Only useful trees were recorded. The prescribed yield of quota sawlogs for the Group was estimated to be 16,523 m^3 per annum.

3. Management Assessment Surveys with No Management Plan

A large section of State Forests north of the Tuross River has been inventoried by this kind of survey during the past decade or so. A brief description of the surveys involved is given in the following:-

(i) Currowan State Forest (In Currowan Management Area)

About 3,440 hectares were covered by this survey. It consisted of four plots of 1.609 kilometre long and 20.12 metres wide.

(ii) Mogo Management Group

This includes most of the State Forests in Mogo and Moruya Management Areas. An area of 22,218 hectares was covered by assessing 125 randomly located, rectangular plots, 0.61 hectare in area.

(iii) Beljillaga Management Investigation Area

Parts of Belimbla, Deau, Nerrigundah and Moruya Crown lands, including part of Dampier State Forest, were included in this investigation It covered an area of 17,569 hectares. This area was assessed along strips 5 metres wide in accessible country and by plots of .405 hectare in inaccessible areas.

(iv) Badja State Forest and Adjoining Crown Lands Sawlog Volume Assessment

This involved measuring only trees over 50 cm d.b.h. in 40 plots, 0.405 hectare in areas, located on 1,372.5 metre grid. Area surveyed was 3,962 hectares.

The assessment of pulpwood availability of private property south of approximately the Bega River (the Pulpwood Supply Zone) was also based on this kind of survey. It involved stratification of the land into three zones - coastal, foothills and tablelands. Six plots were located in the coastal zone, 41 in the foothills and 13 in the tablelands. Plots consisted of two sub-plots, 50 by 20 metres in size (0.1 ha) with each sub-plot 201 metres apart. All trees 19+ cm d.b.h. were assessed. The area covered by the survey was 16,200 ha of which just over 10,000 ha was timbered.

4. Management Assessments Based on Double Phase Sampling

Most of the forest land on existing and proposed State Forests in the area south of the Tuross River and including Nerrigundah and Belimbla Management Areas to the north has been assessed by this kind of survey in two major surveys - the South East District Pulpwood Inventory in 1972 and the Bermagui South Sub-District Management Investigations.

(i) <u>The South-East District Pulpwood Inventory</u>

Phase 1 photo plots were laid down on a 1,372.5 metre grid and the following parameters were evaluated - species type, merchantable gross volume (pulpwood and sawlog, and sawlog only), dominant d.b.h. class, slope, aspect and rock. Altogether 1,260 circular plots, each covering 0.405 ha, were interpreted from 159 metre/cm aerial photographs flown in 1963.

In phase 2, 83 temporary circular plots, 0.405 ha in area, were established on a 5,490 metres grid. Species type, slope, aspect and rock were again assessed. The d.b.h. and merchantable height of all trees 20 cm and greater d.b.h. were measured, and each was classified for merchantability (sawlog, pulpwood - branch and stem, and useless) and species.

The data from the two samples were then analysed by computer and results tabulated and mapped. The total area sampled, including pine plantations, was 237,047 hectares.

A satisfactory correlation between the two phases was achieved for most parameters with the possible exception of species type and sawlog volume, both of which was not unexpected in view of the complex association of species in these areas, and the well-known problem of assessing merchantable sawlog volume in old growth eucalypt forests.

(ii) <u>Bermagui South Sub-District Management Investigation</u>

All State Forests, existing and proposed, in the old Bermagui South Sub-District, except for the Bodalla Management Group, were included. The whole area was subdivided into a north and south stratum, each of which was assessed separately.

The area of economically accessible forest in terms of sawlogs was assessed from 200 air photo plots per stratum and volumes were estimated by measuring 43 randomly located 0.405 ha circular plots in each stratum. Altogether an area of over 64,000 ha was assessed in the north stratum and over 48,000 ha in the south.

The north stratum included the Management Areas of Belimbla, Nerrigundah, Wadbillaga and Tinpot while the south included Mumbulla, Murrabrine and Murrah and part of Brown Mountain Management Areas.

5. Other Management Surveys

These consisted of stratifying areas into volume types, based on species types, height classes and other parameters using aerial photographs combined with field inspections. Usually small areas proposed for logging are involved. In general, only merchantable sawlog volume is assessed. Management Areas covered by this type survey include Buckenbowra and parts of Yadboro and Currowan, and most of the private property forest south of Moruya.

APPENDIX 10.3

INVENTORY OF INDIGENOUS FORESTS

PUBLICLY - OWNED FORESTS

1. Pulpwood Supply Zone

The assessment of pulpwood and sawlog availability in publicly-owned forests in the Pulpwood Supply Zone was based principally on the South East Pulpwood Survey.

The only limit to the forest area was inaccessibility to logging. A forest was considered inaccessible to any form of pulpwood logging if slope exceeded 30° and where rock made roading economically infeasible.

Merchantability limits for pulpwood and sawlogs were as follows:-

Stem pulpwood - Minimum d.b.h. of 20 cm and length 4.9 m.
Branch Pulpwood - From branches and double leaders above sawlogs.
Minimum diameter of 20cm and length 4.9 m.
Sawlog - Minimum d.b.h. of 72 cm and length 4.9 m.

Trees regarded as too defective for either sawlog or pulpwood were classified as useless.

Sawlog plus pulpwood volume in each productivity class and eventually for each management unit, was determined by calculating the average photo plot volume from the Pulpwood Survey data and then converting it to actual volume per hectare by means of a simple linear regression equation in which the actual volume of sawlogs and pulpwood measured in the field-plot sub-sample was related to the average photo-plot volume derived for the same plot.

Sawlog volumes were calculated as 9 percent of sawlog plus pulpwood volume for Management Units in areas other than the Tablelands, and 15 percent for Tableland areas.

2. Mining Timber and Sawlog Supply Zones

The forests in these two Zones have been covered by the Forestry Commission of N.S.W. in several surveys. Wherever possible, assessment of area and available volume was based on management surveys, but since about 60 percent of the forests in these two Zones was not subjected to inventories of this kind, it was necessary to rely on less precise data from the FORWOOD forest resource inventory for the balance of the forest area.

This involved testing a series of simple linear regression equations between values for selected parameters from the FORWOOD photo-plot samples and data from the management surveys in order to ascertain whether the FORWOOD data could provide a reliable estimation of actual volume availability. Areas covered by each management survey were first of all delineated on FORWOOD maps provided by the Forestry Commission of N.S.W. and average photo-plot values for each survey area were calculated. The derived values were then related to the mean values calculated by the management survey.

The average sawlog availability per hectare from <u>each management survey</u> was estimated on two bases depending on the survey:-

(1) net loggable area i.e. the area of forest carrying more than 7.4 m^3/ha of sawlogs greater than 50 cm d.b.h. but excluding inaccessible forest; and

(2) gross area.

Net loggable area was adopted for all survey areas except those covered by the Bodalla and Mogo management surveys. The Kioloa Management Group survey was not included because the forests in the survey area were considered atypical to those in the other areas primarily because of more intensive protection and the longer history of treatment and logging. In other words the analysis was confined only to those forests of approximately the same structure (predominantly dry sclerophyll) and silvicultural condition.

Four separate estimates of volume per hectare were calculated from FORWOOD plot data in each management survey area but the most meaningful was the average sawlog (or 50+ cm d.b.h.) volume per hectare for all plots in the Bodalla, Mogo and Moruya management survey areas and for plots with 7.4 m^3 or greater per hectare in the remaining areas. Volume per hectare in the FORWOOD survey was defined as all useful timber in excess of 10 cm d.b.h.o.b.

This relationship was used as the basis for calculating volumes on areas not covered by the management surveys in each Zone.

The FORWOOD photo-plot volumes estimated for the Bodalla and Mogo survey areas were considered to be comparable to those derived for the other areas because the areas in the latter surveys covered only economically loggable and accessible forest for which FORWOOD volumes 7.4 m^3/ha and greater seemed to provide a satisfactory proxy.

While the precision of the estimating equation is open to question because of the scanty data on which it was based, it is interesting to note that later management surveys by the Forestry Commission of N.S.W. in the Oulla Creek and Badja State Forest areas provided volume estimates not greatly different from those based on the equation. These two areas were not covered by management surveys at the time the inventory for this investigation was made.

Therefore the procedure was to estimate the area of net loggable forest in each Management Area not covered by management surveys based on FORWOOD plots with 7.4 m^3/ha or more merchantable volume 10+ cm d.b.h., and then to calculate sawlog availability in terms of trees 50+ cm d.b.h.o.b. from the estimating equation using the average FORWOOD photo-plot volume for plots 7.4 m^3/ha and greater.

Sawlog volume was classified as consisting of trees 40 cm d.b.h. and over and was derived from the 50+ cm d.b.h. volume equations estimated from the measurement data for the Bodalla CFI plots measured by the author.

Mining timber volumes were based principally on unpublished data from the Forestry Commission of N.S.W. and were confined to the 10 to 30 cm d.b.h. classes.

3. Transition Supply Zone

Because most of this Zone was covered by the Bermagui South Sub-District Management Investigation survey, this formed the main source of data for assessment of volume availability. However this was heavily supported with data from local forestry personnel, including volume typing, and field inspections.

APPENDIX 10.4

AREA AND AVAILABLE MERCHANTABLE VOLUME PER HECTARE FOR MANAGEMENT UNITS OF INDIGENOUS FORESTS

Management Area	Management Unit	Area (ha)	Volume (m^3/ha) SL	Pulp	10+ cm Vol.	MT
1. Pulpwood Supply Zone - Crown Lands						
Bondi	B1MB	9,200	14	91		
Coolangubra	COMB	6,500	14	91		
East Boyd	EBM2	9,100	8	78		
	EBMD	8,750	8	78		
	EBMF	2,450	8	78		
	EBCF	1,100	-	-		
Glenbog	GLMB	12,200	14	91		
	GLMC	3,900	14	91		
Naghi	NAM1	2,850	11	110		
	NAMA	3,050	11	110		
	NAMC	1,150	11	110		
	NAM2	4,250	9	86		
	NAMD	4,450	9	86		
	NAMF	1,600	9	86		
	NAX4	3,000				
	NACF	9,700	-	-		
Nullica-Bimmil	NBM2	6,200	12	112		
	NBMD	6,300	12	112		
	NBMF	2,600	12	112		
Tantowanglo	TAMB	13,800	13	90		
	TAMC	2,600	13	90		
Towambo	TOMB	8,100	12	123		
	TOMC	1,700	12	123		
	TOME	8,100	12	123		
	TOMF	1,700	12	123		
Yambulla North	Y1M2	13,100	11	109		
	Y1MD	11,500	11	109		
	Y1MF	2,200	11	109		

Management Area	Management Unit	Area (ha)	Volume (m^3/ha) SL	Pulp	10+ cm Vol.	MT
Yambulla South	Y2M1	3,600	12	122		
	Y2MA	2,700	12	122		
	Y2MC	600	12	122		
	Y2M2	10,400	10	112		
	Y2MD	7,800	10	112		
	Y2MF	1,800	10	112		
Yurammie - Burragate	YBM1	1,000	10	100		
	YBMA	2,500	10	100		
	YBMC	1,500	10	100		
	YBM2	2,900	9	87		
	YBMD	7,400	9	87		
	YBMF	4,400	9	87		
White Rock	WRME	8,800	14	91		
2. Pulpwood Supply Zone - Private Property						
Bega	BEMD	1,500	8	84		
Bemboka	BKMD	3,100	7	74		
Bondi	B2MD	2,120	7	76		
Burragate	BUMD	5,500	10	115		
Candelo	CAMD	3,170	9	100		
Lower Towamba	LTMD	1,500	11	117		
Nungatta	NUMD	3,300	13	114		
Pambula	PAMD	4,700	9	100		
Wallagoot	WLMD	3,100	11	108		
Wyndham	WYMD	6,970	10	98		
3. Transition Supply Zone - Crown Lands						
Brown Mountain	BMMB	3,000	35	85	74	
	BMMC	1,000	35	85	74	
	BMME	9,500	22	84	57	
	BMMF	3,100	22	84	57	

Management Area	Management Unit	Area (ha)	Volume (m^3/ha)			
			SL	Pulp	10+ cm Vol.	MT
Mumbulla						
	M1MB	2,200	23	87	59	6
	M1MC	600	23	87	59	
	M1ME	7,000	19	87	54	6
	M1MF	1,600	19	87	54	
Murrah	CMME	11,000	15	83	48	6
	CMMF	2,400	15	83	48	
4. <u>Transition Supply Zone - Private Property</u>						
Cobargo	CBMD	5,960	10	98	42	5
Lower Brogo	LBMD	5,500	9	105	41	5
Mumbulla	M2MD	4,200	5	53	36	6
Murrah	PMMD	3,360	18	102	53	6
5. <u>Mining Timber Supply Zone - Crown Lands</u>						
Belimbla	BLME	4,500		47	59	2
	BLMF	8,500		-	59	-
Bodalla	BCX4	4,000		30	36	4
	BCS2	9,000		32	52	4
	BCM2	5,000		35	58	4
Currowan	CUS2	3,000			43	7
	CUSB	3,000			43	-
	CUME	3,000			49	7
	CUMF	3,500			49	-
Mogo	GCS2	8,000			57	6
	GCSB	5,000			57	-
	GCME	2,000			47	6
	GCMF	1,500			47	-
Moruya	MCS2	1,500			52	2
	MCME	8,000			58	2
	MCMF	11,000			58	-
Nerrigundah	NCME	6,000		36	54	2
	NCMF	7,500		-	54	-

Management Area	Management Unit	Area (ha)	Volume (m^3/ha) SL	Pulp	10+ cm Vol.	MT
North Kioloa	KNS1	8,000			87	1
	KNS2	4,000			60	1
	KNMB	2,500			94	1
	KNMO	2,500			94	1
	KNME	6,000			62	1
Quartpot	QCS2	2,500			60	2
	QCME	2,500			51	2
	QCMF	3,000			51	-
South Kioloa	KSS1	7,500			87	1
	KSS2	3,500			60	1
	KSSN	3,500			60	1
	KSMB	750			94	1
	KSMO	750			94	1
	KSME	3,000			62	1
Tinpot	TPME	9,200		30	40	5
	TPMF	5,000		-	40	-
Wadbillaga	WDME	3,500		38	57	2
	WDMF	3,750		-	57	-

6. <u>Mining Timber Supply Zone - Private Property</u>

Management Area	Management Unit	Area (ha)	SL	Pulp	10+ cm Vol.	MT
Bodalla	BPS2	600		32	42	4
	BPME	2,800		35	50	4
Currowan	CPME	1,100			51	7
Mogo	GPME	1,500			54	6
Moruya	MPME	1,500			54	6
North Kioloa	KPS1	1,300			74	2
	KPMB	2,000			49	2
	KPME	2,000			49	2
Quartpot	QPS2	650			63	2
	QPME	650			45	2
South Kioloa	SPS1	1,100			62	2
	SPME	800			50	2
Tinpot	T1ME	400		30	53	2

Management Area	Management Unit	Area (ha)	Volume (m^3/ha)			
			SL	Pulp	10+ cm Vol.	MT
7. Sawlog Supply Zone - Crown Lands						
Araluen	ACM1	1,100			42	
	ACM2	2,400			40	
Badja	BJM1	7,200	47	95	90	
Belowra	BOM1	1,000			56	
	BOM2	3,400			34	
Buckenbowra	BBM2	7,800			39	
Burra Creek	BNM2	10,100			38	
Deau	DEM2	4,000			34	
Murrabrine	MUM1	1,750			56	
	MUM2	1,750			50	
Upper Tuross	UTM1	2,250	14	90	56	
	UTM2	1,500	14	80	47	
Yadboro	YAS2	1,150			20	
	YAM1	7,850			35	
	YAM2	8,000			23	
Yourie	YOM2	2,900			50	
8. Sawlog Supply Zone - Private Property						
Araluen	APM2	750			51	
Belowra	BWM2	800			51	
Buckenbowra	B3M2	750			55	
Burra Creek	B4M2	1,000			63	
Upper Tuross	UPM1	2,200			59	
	UPM2	1,200			59	

Notes:-

SL Sawlog volume:-

(i) Pulpwood Supply Zone - Trees 60+ cm d.b.h. and log length 4.9+ metres.

(ii) Other Supply Zones - Trees 40+ cm d.b.h. and of sawlog quality.

Pulp Pulpwood volume:-

(i) Pulpwood Supply Zone - All timber other than required for sawlogs on slopes less than 30°.

(ii) Other Supply Zones - All timber other than required for sawlogs and mining timber and on slopes less than 20°.

10+ cm Vol. - Merchantable volume in trees 10+ cm d.b.h.o.b. where merchantability is defined as including trees of sawlog and mining timber quality. This category is restricted to the Mining Timber, Sawlog and Transition Supply Zones and is used to determine sawlog yields.

MT - Mining timber volume. This is restricted to trees 10 to 29.9 cm d.b.h. and to Management Units in the Mining Timber and Transition Supply Zones on slopes less than 20°.

APPENDIX 11.1

ESTIMATION OF YIELDS FOR EVEN-AGED EUCALYPT FORESTS

I EVEN-AGED MANAGEMENT STRATEGIES IN THE PULPWOOD SUPPLY ZONE

1. <u>Silvertop Ash Forests</u>

In addition to details already given in Chapter 11, some comment on the procedures used to estimate merchantable yields is considered necessary.

Pulpwood plus sawlog volume was defined as including all volume up to 10 cm s.e.d. in trees 20 cm d.b.h. and over. It was estimated by multiplying the total simulated volume per hectare for each 10 cm d.b.h. class over 20 cm d.b.h. by the proportion of total volume up to 10 cm s.e.d. in each d.b.h. class. Proportions were read from a graph relating percentage volume to 10 cm s.e.d. against individual tree d.b.h. A similar procedure was used to determine sawlog volume per hectare which was based on volume to 30 cm s.e.d. in trees 40+ cm d.b.h. Pulpwood volume per hectare was derived simply by subtracting sawlog volume per hectare from pulpwood plus sawlog volume per hectare.

Where necessary, the pulpwood and sawlog volumes per hectare derived direct from the simulated volumes under each strategy were adjusted for differences between the simulated and actual stands. Under strategy E, no adjustment to simulated yields was considered necessary but simulated pulpwood plus sawlog yields per hectare were reduced by 30 percent under strategy N based on the amount by which simulated yields exceeded actual yields in the Region and on some improvement in yield due to better protection and management.

2. Mixed Species Eucalypt Forests of High Site Quality

Yields were based on messmate, the dominant species occurring in these forests. In Victoria, mean annual volume (pulpwood plus sawlog) increments ranging from 9 to 13 m^3/ha depending on site index and stand density have been estimated by Hall (1956 and 1959) for a rotation of 60 years. Sawlog yields of at least 6 m^3/ha/an at 80 years may be anticipated from thinned even-aged stands of messmate of about average site quality. Within the lower South Coast Region, a mean annual increment of 9.5 m^3/ha for trees 20+ cm d.b.h. was estimated in a 29 years old pure stand of brown barrel (E. fastigata).

It was therefore considered that a pulpwood plus sawlog yield of 9 m^3/ha/an was realistic for these forests and that Hall's (1956) model for estimating mean annual volume increment for messmate was the most satisfactory model to use in this study. The equation representing the growth model was:-

MAI = (0.235*D + 2.465*SI - 0.737*A - 152.0) *0.07

where MAI denotes the mean annual volume increment in m^3/ha/an;

D denotes the Reineke stand density index which is defined in terms of the equivalent number of 25 cm d.b.h. trees per acre;

A denotes age in years; and

SI denotes site index defined as the average height (in feet) of the tallest trees at 50 years of age.

Based on measurement data and other observations in mixed species eucalypt forests of high site quality in the Region, it was decided to adopt a relatively low Reineke stand density index of 340 and a site index of 110 feet (or 33 metres).

3. Mixed Species Eucalypt Forests of Average Site Quality

Again because of limited data within the Region, it was necessary to rely on other sources. However, Curtin's (pers. comm.) observation that the potential productivity of these forests lies somewhere between dry sclerophyll spotted gum and high site quality messmate forests provided a useful starting point for yield estimation purposes.

It was found that yields averaged from (a) unthinned, even-aged dry sclerophyll spotted gum forests within the Region (Furrer, 1971) and (b) unthinned, even-aged mixed species eucalypt forests of high site quality (see previous section) were almost identical with those for site index 27 messmate stands based on Hall's (1956) model. Therefore, it was decided to adopt Hall's model again for estimating yields for those forests using a site index of 27 metres and a stand density index of 340.

The derived yields were adjusted in the same way as that used for silvertop ash forests.

4. <u>Mixed Species Eucalypt Forests of Low Site Quality</u>

The values for basic stand parameters (trees per hectare, basal area per hectare, mean stand d.b.h.) assumed by Alexander (1954) were adopted in this analysis.

Mortality was estimated to average 3.5 percent per annum up to age 50 and 3.0 percent per annum thereafter. Merchantable height to 10 cm s.e.d. was based on observations of these stands in the Region and volumes were calculated by means of the Hardass formula.

Basal area increments per hectare beyond age 50 were based not only on data reported by Alexander (1954) but also on data from remeasured C.F.I. plots at Bodalla State Forest and from Curtin's (1970 b) study. The proportion of total stocking per hectare which was 20+ cm d.b.h. was based on data reported by Curtin (op. cit).

II YIELDS FOR EVEN-AGED MANAGEMENT STRATEGIES IN THE MINING TIMBER SUPPLY ZONE

1. Mixed Species Eucalypt Forests of High Site Quality in Other Than North and South Kioloa Management Areas

Yields for these forests were based initially on the provisional yield table reported by Mann (1955) for thinned messmate forests of about site index 27. Yields in this yield table were increased to reflect a higher site index of 33 metres by using the ratio between total volume per hectare for unthinned messmate stands of site index 27 and 33 metres using Hall's (1956) model.

A residual basal area of 21 m^2/ha was aimed at following thinning and the average d.b.h. of the retained stand was assumed to be the same as that in Mann's (1955) yield table.

2. Mixed Species Eucalypt Forests of High Site Quality in North and South Kioloa Management Areas

Furrer (1971) considered that these forests could not be regenerated successfully following logging unless the site was properly prepared (pushed, heaped and burnt) and planted. Blackbutt, the species currently preferred by the Forestry Commission of N.S.W. for planting these sites, was adopted. It was decided to use the provisional yield table developed by Curtin (1969) for thinned, even-aged stands of blackbutt rather than attempt to simulate a new yield table based on extremely limited data.

3. Mixed Species Eucalypt Forests of Average Site Quality

A hypothetical yield table was constructed and was based on data from several sources, in particular:-

(a) Furrer's (1971) yield table for even-aged dry sclerophyll spotted gum forests which represented the lower limit for yield estimation, and

(b) Mann's (1955) provisional yield table for site index 27 messmate stands.

The following assumptions were made:-

(i) Residual basal area of the stand following non-commercial thinning to 1,000 trees/ha was assumed to be 11.5 m^2/ha.

(ii) The following periodic annual increments for d.b.h. and basal area were adopted for the retained stands following thinning:-

Age (Years)	D.b.h. (cm)	Basal Area (m^2/ha)
10 to 25	N.R.	1.0
26 to 40	0.9	0.8
41 to 60	0.7	0.6
61 to 80	0.6	0.5

(iii) Residual basal area at thinning was assumed to be 18.4 m^2/ha.

Volumes were determined by means of the Hardass formula using log lengths based on data from the C.F.I. plots at Bodalla State Forest.

APPENDIX 11.2

DETAILS OF GROWTH FUNCTIONS AND OTHER ASPECTS OF SIMULATION MODEL USED TO ESTIMATE YIELDS FOR SELECTION MANAGEMENT STRATEGIES

GROWTH TO FIRST LOGGING

The silvicultural class specified in each run identifies the growth equation to be used. For Silvicultural Class A (virgin or unmanaged forests), growth was assumed to be in equilibrium with drain due to mortality.

For extensively-managed (Silvicultural Class B) forests, growth was based on the following two equations:-

(1) Spotted gum forests

$$VIS = -0.016\ (V-200) - 0.000086\ (V-200)^2$$

(2) Mixed species eucalypt forests

$$VIM = -0.024\ (V-250) - 0.000092\ (V-250)^2$$

where VIS and VIM denote the nett periodic annual volume increment over a period of 10 years for spotted gum and mixed species eucalypt forests respectively for trees 10+ cm d.b.h. in m^3/ha/an;

V denotes the standing volume including defect available at the beginning of the growth cycle for trees 10+ cm d.b.h. in m^3/ha.

Both equations were estimated from the growth data for the 50 continuous forest inventory plots measured by the author at Bodalla State Forest (see Appendix 10.1). A second-degree polynomial was used such that net periodic growth equalled zero at 200 m^3 and 250 m^3 per hectare for spotted gum and mixed species eucalypt forests respectively. These upper limits for positive net growth were based partly on the Bodalla State Forest plot data and partly on standing volumes in old-growth forests in the Region. They were considered to be conservative and therefore growth was more prone to under-estimation than over-estimation particularly in the more productive high site quality forests. Where the standing volume exceeded 200 or 250 m^3/ha respectively, zero growth was assumed in the simulation model.

The estimates from these equations apply only to average site quality forests and therefore must be adjusted to reflect the productivity of other site qualities. High site quality forests were assumed to grow at twice the rate estimated from the above two equations. This was based on the ratio between the mean annual increments estimated earlier in this chapter for even-aged high and average site quality forests.

Volume per hectare in planning period "n" is therefore calculated by the following general equation:-

(a) In planning period 0, set $V_o = V$

where V denotes the merchantable volume per hectare inventoried in Chapter 11 for trees 10+ cm d.b.h.

(b) In planning period n,

Spotted Gum: $V_n = V_{n-1} + (-0.016(V_{n-1}-200) - 0.000086(V_{n-1}-200)^2 * 5$

Mixed Eucalypts: $V_n = V_{n-1} + (-0.024(V_{n-1}-250) - 0.000092(V_{n-1}-250)^2) * 5$

For intensively-managed (Silvicultural Class C) forests, growth was assumed to be 50 percent higher than that estimated by the basic equations. This was based on results reported for mixed species eucalypt forests in central coastal New South Wales (Curtin 1970). It means that growth in average site quality Silvicultural Class C forests and in high site quality Silvicultural Class C forests will be 1.5 and 3 times that estimated by the two basic growth equations.

GROWTH SUBSEQUENT TO FIRST LOGGING

Logging implies either Silvicultural Class B or Silvicultural C forests, that is, some degree of formal management. The basic equations adopted for Silvicultural Class B and C forests up to first logging were again used. The main difference relates to the length of the growth cycle and the period over which growth is estimated. The length of each growth cycle is 10 years which is equal to the period covered by the measurement data in the Bodalla State Forest C.F.I. plots. The total period over which the forest is grown is equal to the cutting cycle which, combined with the level of timber removals assumed, will result in sustained yield from the forest. Two or more ten-year growth cycles are required in the estimation of total growth over the cutting cycle.

A range of cutting cycle lengths and timber removal levels were tested by means of the simulator. With the exception of the high site quality forests, the functions adopted for these two parameters were based on the proximity of the estimated yields to sustained yield production. For high site quality forests, it was assumed that since there would be little natural regeneration following logging, all merchantable growing stock would be removed by the end of the first cutting cycle. In all cases, the number of cutting cycles was at least two, and where the period covered by the two cycles did not exceed 50 years, (the length of the planning horizon), further cycles were repeated until it did.

ESTIMATION OF LOGGING YIELDS

The following linear relationship was assumed between the volume cut per hectare and the total volume of timber per hectare available for logging:-

$$C = k + p.V$$

where C denotes the volume removed by logging in m^3/ha;

V denotes the total volume of timber available for logging i.e. volume in trees 10+ cm d.b.h.o.b., in m^3 per hectare;

and k and p denote the regression constant and coefficient respectively.

This equation was used as the basis for estimating mining timber yields at all but first logging where it was assumed that the volume of mining timber removed would be equal to that estimated as being available in each management unit by the inventory described in Chapter 10.

At subsequent loggings, the volume cut per hectare was estimated as being equal to a proportion of C, the total volume of timber removed at logging. Thus,

$$M = m.C$$

where M denotes the volume of mining timber removed per hectare in m^3 per hectare;

m denotes the proportion of the total volume of timber removed (C) expressed as a decimal.

The following values for m were adopted:-

Management System S - 0.10

Management System Q - 0.20

The value of 0.10 for System S was based on the ratio between current mining timber removals and total timber removals (other than pulpwood) from Crown lands in the South Coast Forestry District using data from recent Annual Reports of the Forestry Commission of New South Wales but adjusting for higher mining timber yields from treated areas in the District.

The value of 0.20 for System Q was principally based upon the yield tables derived earlier for even-aged forests.

Sawlog yield were therefore calculated by simply deducting the volume of mining timber removed per hectare from the total volume of timber cut, C. The size of the sawlog volume cut is thus very much dependent on the magnitude of C which for most management units is dictated by the yield that can be sustained from the forest.

To simplify discussion, the values adopted for k and p in the linear relationship between C and V, are summarized in Table 11.2.1.

TABLE 11.2.1

Values of linear regression constants (k) and coefficients (p) adopted for estimating the volume per hectare cut at each logging under selection systems.

Productivity Grouping	Selection System	First Logging k	First Logging p	Subsequent Loggings k	Subsequent Loggings p
1. High site quality spotted gum	S	0	0.50	0	0.50
	Q	0	0.50	0	0.50
2. Average site quality spotted gum	S	0	0.30	0	0.30
	Q	0	0.40	0	0.40
3. High site quality mixed eucalypts	S	0	0.50	0	0.50
	Q	0	0.50	0	0.50
4. Average site quality mixed eucalypts	S	-16.3	0.83	0	0.50
	Q	-16.3	0.83	0	0.50

It will be recalled that the minimum sawlog cutting d.b.h. was assumed to be 40 cm; thus all trees 40 cm and over can be logged provided that a sustained or increasing level of yield can be maintained. The volume per hectare of 40+ cm d.b.h. trees may be determined for average site quality forests by means of the following equations:-

Spotted Gum: $V_{40} = 3.25 + 0.58\ V_n$

Mixed Eucalypts: $V_{40} = -16.3 + 0.83\ V_n$

where V_{40} denotes the volume of 40+ cm d.b.h. timber available in m^3 per hectare;

and V_n denotes the volume of 10+ cm d.b.h. timber available in year "n" in m^3 per hectare.

Both equations were estimated from the remeasurement data from the Bodalla State Forest C.I.F. plots. They indicate that the maximum sawlog cut from average sites will be about 60 percent of the total volume in trees 10 cm d.b.h. and over.

APPENDIX 11.3

PRODUCTION COSTS FOR MANAGEMENT STRATEGIES PROPOSED FOR PLANNING MODELS

RADIATA PINE PLANTATIONS

Costs adopted for Forestry A, B and C strategies in the comparative analysis were again used for the same strategies in the planning model except in the Bombala Plantation working circle where almost total clearing and more intensive cultivation than on the farmlands is necessary. The cost of establishment adopted (excluding surveys) was:-

Field Cost	$210 per hectare
Administrative	$105 per hectare
Total	$315 per hectare

The social opportunity cost of the farmlands was assumed to be equal to $375 per hectare. This is the present value of the net social benefit per hectare derived earlier for the Beef Grazing A alternative in the comparative land use study, less a small allowance for development costs.

EUCALYPT FORESTS

Pulpwood Production Strategies

Strategy N   Costs per hectare adopted for this strategy are summarized in Table 11.3.1.

The basis of these costs was as follows:-

(a) Field costs include all wages, materials and plant hire incurred on field operations plus a loading of 10 percent for overheads.

(b) Administrative costs are equal to 50 percent of field costs.

(c) Roading costs were calculated as follows:-

(i) Foothills and Tablelands. The Forestry Commission is responsible for all primary access roads which are constructed at a density of 8 kms per 1,000 ha of forest logged plus a further 30 percent more for surveys and feeder roads. Cost per kilometre of primary access roads was estimated to be $3,250.

(ii) Mountains. Again roading density was assumed to be 8 kilometres per 1,000 ha of forest land but cost per kilometre was increased to $4,875 or 50 percent that for the foothills and tablelands because of greater cut and fill, and more rock excavation.

TABLE 11.3.1

Year	Item	Field Cost ($/ha)	Administrative Cost ($/ha)
	I First Rotation Costs (R years)		
0	(i) Roading - Foothills and Tablelands	28.6	14.3
	- Mountains	42.9	21.5
	(ii) Culling and hazard reduction	3.8	1.9
	(iii) Ripping and planting log dumps, plus enrichment planting or aerial seeding where necessary		
	- Dry sclerophyll forests and tall woodland	8.3	4.1
	- Wet sclerophyll forests	16.0	8.0
0 to R	Annual costs of protection and maintenance		
	- Foothills and Tablelands	0.90	0.45
	- Mountains	1.00	0.50
	II Second and Subsequent Rotations		
R	(i) Road reconstruction		
	- Foothills and Tablelands	5.7	2.8
	- Mountains	8.6	4.3
	All other costs are as for first rotation		

(iii) Expenditure incurred on the Imlay Road connecting the chipmill to the Tablelands, estimated at \$2,000,000 (Davies et al, 1974) and the Edrom Road connecting the Princess Highway to Edrom, costing over \$300,000, was treated as sunk costs.

(iv) Costs for areas already well roaded such as Mumbulla and Murrah Management Areas were reduced accordingly.

(d) Culling and Hazard Reduction

This was estimated to cost \$60/hectare and applies to 5 percent of the area logged. Thus an allocated cost of \$3.5 per hectare <u>plus</u> 10 percent for overheads was adopted.

(e) Ripping and Planting of Log Dumps

The estimated cost of carrying out this operation was \$75 per hectare including \$25 per hectare for seedlings and was applied to 10 percent of the logged area. An allocated cost <u>plus</u> 10 percent for overheads of \$8.3 per hectare was therefore adopted.

It was applied to all forest types. Stocking was at 400 trees per hectare.

(f) Aerial Seeding or Enrichment Planting of Wet Sclerophyll Forests

It was assumed that 50 percent of these areas would have to be aerially seeded at a cost of $14 per hectare (Felton, pers. commun.) based on Tasmanian experience. Thus the allocated cost plus 10 percent overheads was estimated to be $7.7/ha.

Alternatively 20 percent of the area was assumed to be planted at 200 t/ha at a cost of $35/ha or $7/ha. With 10 percent for overheads, this was equal to $7.7/ha as in the case of aerial seeding.

(g) Annual Costs

This category of costs included the following:-

(i) Road maintenance. Management was assumed to maintain only primary access roads in a serviceable condition plus a small proportion of minor feeder roads.

A cost of $37.5 per kilometre per annum was adopted for areas in the foothills and tablelands at a density of 8 kilometres of road per 1,000 ha.

(ii) Control Burning and Top Disposal. This was estimated to cost $0.12/ha/annum.

(iii) Other Fire Protection Costs (Maintenance of Firelines, etc.).

A cost of $0.20/ha/an was estimated.

(iv) Miscellaneous Surveys (Design and Management Surveys)

A cost of $0.05/ha/an was adopted.

(v) Research

The allocated cost for this item was estimated as being $0.15/ha/an.

(vi) Total Costs

The above costs plus an allowance for contingencies was estimated to be $0.82/ha/an for field costs plus 10 percent overheads in the foothills and Tablelands.

A further $0.10/ha/an was added to cover higher road maintenance and research costs in the mountain areas particularly where granite-derived soils occur.

(h) Road Reconstruction Costs

Based on costs connected with these operations in other areas in the Region the cost of road reconstruction was estimated to be equal to 20 percent of the original construction cost.

(i) Remarks

In general where logging is spread over a relatively large area of 500 hectares, roading costs tend to vary directly with the area. In smaller areas, this would not be so but since small areas are not associated with pulpwood logging operations, even where small coupe sizes are involved, the proportionality assumption was considered to be reasonable.

Strategy E. The only variations to Strategy N costs were as follow:-

(i) All ripping and planting of log dumps, hazard reduction and cull removal, and any further enrichment planting or aerial seeding was assumed to be replaced by clearing (push, heap and burn), planting and vermin control estimated to cost $115 per hectare plus 10 percent for overheads.

TABLE 11.3.2

Year	Item		Field Cost ($/ha)	Administrative Cost ($/ha)
	I First Rotation Costs (R years)			
0	(i) Roading (as for strategy N)			
	(ii) Clearing		110.0	55.0
	(iii) Cultivation		49.5	24.8
	(iv) Planting - Seedlings	36.6		
	- Planting plus cartage	38.5		
	- Refilling	3.9	79.0	39.5
	(v) Fertilizer		17.6	8.8
	(vi) Vermin Control		2.2	1.1
	(vii) Surveys		11.0	5.5
I	(i) Fertilizer		39.6	19.8
	(ii) Cultivation for weed control		11.0	5.5
Annual recurring costs			4.0	2.0
	II Second and Subsequent Rotation Costs			
	As for first rotation except that roading costs fall to the level adopted in Strategy N and clearing costs to zero.			

(ii) Dry Sclerophyll Forests

Natural regeneration plus all other operations outlined for strategy N were again adopted for costing purposes but a further $60 per hectare plus 10 percent for overheads was included at age 5 to 10 for non-commercial thinning of the regenerated stand from 2,500 t/ha to 1,000 t/ha.

(iii) Annual Costs

These were increased to $1.5/ha/an to cover some follow up treatment of stands.

Strategy I

Basic costs for this strategy are provided in Table 11.3.2. Roading costs were assumed to be identical to strategy N. The basis for other costs were as follow:-

Clearing This consisted of pushing, heaping into windrows, raking and burning, all material not considered usable for milling. It involved 6.0 hours per hectare operation of a Caterpillar D7 @ $11/hour plus 9 hours labour at $2.3 per man hour.

Cultivation The site was assumed to require two ploughings or one ploughing and ridging. This required 2.7 hours operation of a D7 and 3 man hours of labour at the same rates as for clearings.

Planting 1,667 seedlings/hectare of E. globulus were assumed to be planted at a cost for the seedlings of $20 per 1,000. Planting involved 14 man-hours/hectare at a cost of $2.3/man-hour plus cartage and overheads. Refilling was assumed to equal 10 percent of the original area planted.

Fertilizer at Establishment 113 gm of superphosphate were applied per seedling at a cost of $32 per tonne for superphosphate and $10 per hectare for labour.

Vermin Control This was estimated to equal $2/hectare.

Surveys A nominal charge of $11/hectare was adopted and was based on the experience of the Forestry Commission of N.S.W. in their radiata pine plantations.

Fertilizer in Year 1 227 gm of Hy-Gold/seedling are applied at an unsubsidized cost of $67/tonne and a labour cost of $10/hectare was assumed to be required.

Weed Control in Year 1 An interrow cultivation was considered to be needed at an estimated cost of $10/hectare based on A.P.M. experience.

Clearing was not considered to be necessary in second and subsequent rotations but all their operations including cultivation were adopted.

TABLE 11.3.3

Year	Item	Field Cost ($/ha)	Administrative Cost ($/ha)
	I Costs at First Logging		
0	Road Construction		
	(i) Major (7.3 m width)	11.7	5.8
	(ii) Secondary (5.5 m width)	9.9	5.0
	(iii) Feeder (4.2 m width)	19.8	9.9
	Total	41.4	20.7
	Annual recurring cost of maintenance and protection		
	(i) Sustained yield management areas		
	Bodalla	0.6	0.3
	North and South Kioloa	0.90	0.45
	(ii) Coastal hills, dry sclerophyll forests	0.6	0.3
	(iii) Mountains	0.6	0.3
	II Costs at Second and Subsequent Loggings. Every L Years		
L, 2L	Road Reconstruction		
	(i) Major roads	1.76	0.88
	(ii) Secondary roads	1.65	0.82
	(iii) Feeder	2.48	1.24
	Total	5.89	2.94

Annual costs were related to those typical of radiata pine plantations in the Region. A cost of $4/ha was adopted compared with $7/ha for radiata pine plantations.

Strategies for Mining Timber and/or Sawlog Production

Strategy S Costs per hectare are presented in Table 11.3.3 and were derived as follow:-

Road Construction

(i) Major Access Roads. (7.3 metre width formation). The allocated cost per hectare for external roads varied according to length required but the cost per kilometre was assumed to be similar to that for major internal access roads. The cost of constructing major internal roads for a previously unlogged area was based on the following assumptions:-

(a) Roading intensity. 2 km/1,000 ha.

(b) Cost of construction. $5,000/km <u>plus</u> $300/km for surveys.

(ii) Secondary Access Roads (5.5 metre width formation).

(a) Roading intensity. 5 km/1,000 ha.

(b) Cost of construction. $1,600/km <u>plus</u> $200/km for surveys.

TABLE 11.3.4

Year	Item	Field Cost ($/ha)	Administrative Cost ($/ha)
	I Costs at First Logging		
0	Road Construction. As for Strategy S		
	Timber Stand Improvement (T.S.I.)		
	(i) Areas previously intensively logged with some T.S.I.	49.5	24.8
	(ii) Areas previously extensively logged with little or no T.S.I.		
	(a) Foothills	60.5	30.3
	(b) Mountains	71.5	35.8
	II Costs and Subsequent Logging and Thinning (T_i Years)		
$0 + T_i$	Road Reconstruction. As for Strategy S		
	III Costs at Subsequent Rotations		
$R_1, R_2 - R_n$	Timber Stand Improvement	20.0	10.0
	Annually Recurring Costs		
	(i) Bodalla and Kioloa Management Areas. As for Strategy S		
	(ii) Other Management Areas:-		
	(a) Foothills	0.60	0.30
	(b) Mountains	0.90	0.45

(iii) Feeder Roads (4.2 metre width formation).

(a) Roading intensity. 15km/1,000 ha.

(b) Cost of construction. $1,100/km plus $100/km for surveys.

Annual Recurring Costs. These were based on the experience of the Forestry Commission of N.S.W. allocated appropriately.

Road Reconstruction

The following costs per kilometre were adopted:-

Major Roads	- $800/km
Secondary Roads	- $300/km
Feeder Roads	- $150/km

Reconstruction costs are needed for re-alignment of roads to reduce log haulage costs.

Strategy Q

Field and administrative costs for this strategy are presented in **Table 11.3.4.**

The same costs for roading construction and reconstruction used for strategy **S** were applied to all Management Areas with modifications for existing roading systems where appropriate. However with the exception of Bodalla and Kioloa Management

Areas where the same as for strategy S were adopted, annual costs were increased slightly to allow for more intensive production.

Timber stand improvement costs were varied according to the silvicultural condition of the forest and as pointed out earlier in chapter 11 were restricted to dry sclerophyll forests only. This was assumed to require removal of unmerchantable trees by means of chainsaw felling and where necessary tractor clearing and some site disturbance. For areas which had been previously logged intensively with some silvicultural improvement treatment, this was estimated to cost $49.5 per hectare including 10 percent for overheads. For areas which had been less intensively logged and which had received little or no silvicultural treatment, costs were estimated to be as follow:-

Foothill country	-	$60.5/ha
Mountains	-	$71.5/ha

Where it was possible to integrate pulpwood logging operations, timber stand improvement was estimated to cost only half the level of the above costs. This was adopted for Bodalla, Nerrigundah, Tinpot and Wadbillaga Management Areas.

Strategies T and J

Costs for road construction and reconstruction and annual maintenance and protection costs were assumed to be identical to Strategy Q. However regeneration costs in the wet sclerophyll forests at initial logging (including overheads) were based on clearfelling and planting the area as follow:-

Tractor clearing, heaping or windrowing	-	$66.0/ha
Burning	-	$ 5.5/ha
Planting:-		
Plants delivered on site at 816 trees/ ha at a cost of $22/1 000	-	$19.8/ha
Planting by hand	-	$38.5/ha
Total		$129.8/ha

Re-establishment costs were estimated to total $46.2/ha for pushing, heaping and burning and $58.3/ha as above for planting.

Administrative costs amounted to 50 percent of these field costs or $64.9/ha at establishment and $52.5/ha at re-establishment.

Costs of tractor clearing average site quality spotted gum forests were assumed to be equal to timber stand improvement costs for areas previously extensively logged with little or no silvicultural treatment.

APPENDIX 12.1

PULPWOOD PRICES - EUCALYPT FORESTS

Management Area	Distance from Edrom (km)	Haulage Cost ($/m^3)	Logging ($/m^3)	Total ($/m^3)	Residual Value ($/m^3) solid	Net Value $ per m^3 gross
1. OLD GROWTH FORESTS (Delivered Price $11.97/m^3)						
Pulpwood Zone - Crown Lands						
Bondi	77	3.47	6.05	9.52	2.45	1.85
Coolangubra	88	3.96	6.05	10.01	1.96	1.46
East Boyd	19	.86	6.35	7.21	4.76	3.70
Glenbog	113	5.09	6.65	11.74	Min .55	.21
Naghi	35	1.58	6.35	7.93	4.04	3.12
Nullica-Bimmil	42	1.89	6.35	8.24	3.73	2.87
Tantawanglo	92	4.14	6.65	10.79	1.18	.83
Towamba	72	3.24	6.95	10.19	1.78	1.31
White Rock	64	2.88	6.35	9.23	2.74	2.08
Yambulla North	45	2.03	6.35	8.38	3.59	2.76
Yambulla South	47	2.12	6.35	8.47	3.50	2.69
Yurammie-Burragate	61	2.75	6.35	9.10	2.89	2.19

Management Area	Distance from Edrom (km)	Haulage Cost ($/m^3)	Logging ($/m^3)	Total ($/m^3)	Residual Value ($/m^3) solid	Net Value per m^3 gross
<u>Transition Zone - Crown Lands</u>						
Badja	240	10.80	6.65	N.R.	Minimum	.21
Brown Mt.	145	6.53	6.65	N.R.	Minimum	.21
Mumbulla	119	5.36	6.35	N.R.	Minimum	.21
Murrabrine	150	6.75	6.95	N.R.	Minimum	.21
Murrah	129	5.81	6.35	N.R.	Minimum	.21
Yourie	177	7.97	6.95	N.R.	Minimum	.21
Upper Brogo	146	6.57	6.95	N.R.	Minimum	.21
Upper Tuross	209	9.41	6.35	N.R.	Minimum	.21

Management Area	Distance from Edrom (km)	Haulage Cost ($/m^3)	Logging ($/m^3)	Total ($/m^3)	Residual Value ($/m^3) solid	Net Value per m^3 gross
Pulpwood Zone - Private Property						
Bega	93	4.19	7.00	11.19	~~Minimum~~	.62
Bemboka	134	6.03	7.00	13.03	Minimum	Min .21
Bondi	69	3.11	7.00	10.11	~~Minimum~~	1.49
Burragate	58	2.61	7.00	9.61	~~Minimum~~	1.89
Candelo	71	3.20	7.00	10.20	~~Minimum~~	1.42
Lower Towanba	32	1.60	7.00	8.60	~~Minimum~~	2.70
Nungatta	68	3.06	7.00	10.06	~~Minimum~~	1.53
Pambula	48	2.40	7.00	9.40	~~Minimum~~	2.06
Wyndham	71	3.20	7.00	10.20	~~Minimum~~	1.42
Wallagoot	64	2.88	7.00	9.88	~~Minimum~~	1.67

Management Area	Distance from Edrom (km)	Haulage Cost ($/m^3)	Logging ($/m^3)	Total ($/m^3)	Residual Value ($/m^3) solid	Net Value per m^3 gross
<u>Transition Zone - Private Property</u>						
Cobargo	145	6.53	7.00	N.R.	Minimum	.21
Lower Brogo	121	5.45	7.00	N.R.	Minimum	.21
Mumbulla	119	5.36	7.00	N.R.	Minimum	.21
Murrah	129	5.81	7.00	N.R.	Minimum	.21
Upper Tuross	209	9.41	7.00	N.R.	Minimum	.21

N.R. - Not required

Management Area	Distance from Edrom (km)	Haulage Cost ($/m^3)	Logging ($/m^3)	Total ($/m^3)	Residual Value ($/m^3)	Net Value ($/m^3 gross)
2. REGROWTH AND EXTENSIVELY - MANAGED PLANTATIONS (Delivered Price $11.12/m^3)						
Pulpwood Zone						
Bondi	77	3.47	5.0	8.47	2.65	2.28
Coolangubra	88	3.96	5.0	8.96	2.16	1.83
East Boyd	19	.95	5.0	5.95	4.17	4.54
Glenbog	113	5.09	5.0	10.09	1.03	.82
Naghi	35	1.75	5.0	6.75	4.37	3.82
Mullica-Bimmil	42	2.10	5.0	7.10	4.02	3.51
Tontawanglo	92	4.14	5.0	9.14	1.98	1.67
Towamba	72	3.24	5.0	8.24	2.88	2.48
White Rock	64	2.88	5.0	7.88	3.24	2.81
Yambulla North	45	2.25	5.0	7.25	3.87	3.37
Yambulla South	47	2.35	5.0	7.35	3.77	3.28
Yurammie-Burragate	61	2.75	5.0	7.75	3.37	2.92

Management Area	Distance from Edrom (km)	Haulage Cost ($/m^3)	Logging ($/m^3)	Total ($/m^3)	Residual Value ($/m^3)	Net Value ($/m^3 gross)
<u>Transition Zone - Crown Lands</u>						
Badja	240	10.80	5.0	15.80	Minimum	.21
Brown Mt.	145	6.53	5.0	11.53	Minimum	.21
Munbulla	119	5.36	5.0	10.36	~~Minimum~~	.57
Murrabrine	150	6.75	5.0	11.75	Minimum	.21
Murrah	129	5.81	5.0	10.81	Minimum	.21
Yourie	146	7.97	5.0	12.97	Minimum	.21
Upper Brogo	209	6.57	5.0	11.57	Minimum	.21
Upper Tuross	177	9.41	5.0	14.41	Minimum	.21

Management Area	Distance from Edrom (km)	Haulage Cost ($/m^3)	Logging ($/m^3)	Total ($/m^3)	Residual Value ($/m^3)	Net Value ($/m^3 gross)
Pulpwood Zone PULPEP and PULPEP1 Private Property (No allowance for H & M)						
Bega	93	4.19	5.80	9.99	~~Minimum~~	1.02
Bemboka	134	6.03	5.80	11.83	Minimum	.21
Bondi	69	3.11	5.80	8.91	~~Minimum~~	1.99
Burragate	58	2.61	5.80	8.41	~~Minimum~~	2.44
Candelo	71	3.20	5.80	9.00	~~Minimum~~	1.91
Lower Towanba	32	1.60	5.80	7.40	~~Minimum~~	3.35
Nungatta	68	3.06	5.80	8.86	~~Minimum~~	2.03
Pambula	48	2.40	5.80	8.20	~~Minimum~~	2.63
Wyndham	71	3.20	5.80	9.00	~~Minimum~~	1.91
Wallagoot	74	2.88	5.80	8.68	~~Minimum~~	2.20

Management Area	Distance (km)	Haulage Cost	Logging	Total	Net Value ($\$/m^3$ gross)
3. FAST-GROWN PLANTATIONS (Delivered Price $\$9.80/m^3$)					
Bondi	77	3.47	4.50	7.97	1.72
Coolangubra	88	3.96	4.50	8.46	1.23
East Boyd	19	.95	4.50	5.45	4.24
Glenbog	113	5.09	4.50	9.59	0.21
Naghi	35	1.75	4.50	6.25	3.44
Nullica-Bimmil	42	2.10	4.50	6.60	3.09
Tantawanglo	92	4.14	4.50	8.64	1.05
Towamba	72	3.24	4.50	7.74	1.94
White Rock	64	2.88	4.50	7.38	2.31
Yambulla North	45	2.25	4.50	6.75	2.94
Yambulla South	47	2.35	4.50	6.85	2.84
Yurammie-Burragate	61	2.75	4.50	7.25	2.44

APPENDIX 12.2

LOGICAL SAWMILL SITES BY MANAGEMENT AREAS

Supply Zone	Tenure	Management Area	Logical Mill Site	
			Prior to 1995/96	1995/96+
Pulpwood	Crown	Coolangubra	Bombala	Nimitabel
		East Boyd	Eden	Eden
		Glenbog	Nimmitabel	Nimmitabel
		Naghi	Eden	Eden
		Nullica-Bimmil	Eden	Eden
		Tantawanglo	Bombala/Bega	Nimmitabel
		Towamba	Eden	Eden
		Yambulla North	Eden	Eden
		Yambulla South	Eden	Eden
		Yurammie-Burragate	Eden	Eden
		White Rock	Bombala/Eden	Eden
	Private Property	Bega	Bega	Cobargo
		Bemboka	Bega	Cobargo
		Bondi	Bombale	Nimmitabel/Cobargo
		Burragate	Eden	Eden
		Candelo	Bega	Eden
		Lower Towamba	Eden	Eden
		Nungatta	Bombala	Eden
		Pambula	Eden	Eden
		Wallagoot	Bega	Eden
		Wyndham	Bega/Eden	Eden

Supply Zone	Tenure	Management Area	Logical Mill Site	
			Prior to 1995/96	1995/96+
Transition	Crown	Brown Mt.	Bega	Nimmitabel
		Mumbulla	Bega/Cobargo	Cobargo
		Murrah	Bega	Cobargo
	Private Property	Cobargo	Cobargo	Cobargo
		Lower Brogo	Cobargo	Cobargo
		Mumbulla	Bega/Cobargo	Cobargo
		Murrah	Bega	Cobargo
Mining Timber	Crown	Belimbla	Nerrigundah	Bodalla
		Bodalla	Narooma	Bodalla
		Currowan	Batemans Bay	Batemans Bay
		Mogo	Batemans Bay	Batemans Bay
		Moruya	Moruya	Bodalla
		Nerrigundah	Nerrigundah	Bodalla
		North Kioloa	Ulladulla	Ulladulla
		Quartpot	Batemans Bay	Batemans Bay
		South Kioloa	Batemans Bay	Batemans Bay
		Tinpot	Cobargo	Cobargo
		Wadbillaga	Cobargo	Cobargo
	Private Property	Bodalla	Narooma	Bodalla
		Currowan	Batemans Bay	Batemans Bay
		Mogo	Batemans Bay	Batemans Bay
		Moruya	Moruya	Bodalla
		North Kioloa	Ulladulla	Ulladulla
		Quartpot	Batemans Bay	Batemans Bay
		South Kioloa	Batemans Bay	Batemans Bay
		Tinpot	Cobargo	Cobargo

Supply Zone	Tenure	Management Area	Logical Mill Site	
			Prior to 1995/96	1995/96+
Sawlog	Crown	Araluen	Moruya	Bodalla
		Badja	Nimmitabel	Nimmitabel
		Belowra	Nerrigundah	Bodalla
		Buckenbowra	Batemans Bay	Batemans Bay
		Burra Creek	Moruya	Batemans Bay
		Deau	Nerrigundah	Bodalla
		Murrabrine	Cobargo	Cobargo
		Upper Tuross	Nimmitabel	Nimmitabel
		Yadboro	Ulladulla	Ulladulla
		Yowrie	Cobargo	Cobargo
	Private Property	Araluen	Moruya	Bodalla
		Belowra	Nerrigundah	Cobargo
		Buckenbowra	Batemans Bay	Batemans Bay
		Burra Creek	Moruya	Bodalla
		Upper Tuross	Nimmitabel	Nimmitabel

APPENDIX 12.3

COST OF SAWMILLING (M)

Man-day production was based on unpublished data supplied by the New South Wales Government Statistician from manufacturing statistics for sawmills in the Shires of Eurobodalla, Imlay and Mumbulla and the Muncipality of Bega in 1968/69 when it averaged 1.26 m^3 sawn or approximately the same as the State average. Although man-day productivities for individual mills in the Region were not available, an industry spokesman considered that they ranged from .68 to 4.72 m^3 sawn for New South Wales with a modal value of 1.53 m^3. An average productivity figure of 1.80 m^3 sawn /~~man-day~~ was adopted for mills during planning periods 0 to 3 and 3.20 m^3 sawn per day during subsequent periods. Employment levels for mills of capacities 5 360 m^3 and 16 521 m^3 were based on these productivities.

Capital investment for the larger mill was based on costs reported for one large hardwood sawmill **(for example, Lembke 1972).** An average investment outlay of \$50/m^3 sawn was estimated. For the smaller mill, an investment of \$39/m^3 was adopted based on 75 percent of the larger mill's and was arrived at from average depreciation rates for the log sawmilling industry in Australia (Industries Assistance Commission 1974) assuming an average residual life of 7 years.

Administrative costs for the small mill were based on 1 mill manager at a salary of \$10,000, and an office clerk at \$5,000 plus overheads of \$6,000. For the larger mill, three management staff paid \$10,000 per annum, one at \$7,000 and two at \$4,000 plus \$20,000 were assumed.

Insurance was calculated as 2 percent of the average profit bearing capital of plant and buildings used for determining normal profit i.e. of $((I - R)(N + 1)/2N) + R$ where I is the initial capital cost and R the salvage value after N years life. A normal profit rate of 15 percent was again used as in Chapter 6 for the radiata pine sawmill.

Depreciation was estimated on a straight line basis assuming a 30 year life and 5 percent salvage value for buildings and 10 year life and 10 percent salvage value for plant.

As in the case of radiata pine sawmilling, direct wages per man hour of \$2.66 (or \$4 872 per annum) was obtained from the survey of weekly earnings for adult males in the other manufacturing industry (Commonwealth Bureau of Census and Statistics, 1973), and includes overtime of 5.4 hours per week.

Indirect labour was assumed to be 20 percent of direct labour and allows 15% for workers' compensation, 2.5% payroll tax and 2.5% for incentive payments.

Other manufacturing costs covers maintenance and repairs, fuel, oil, power and was based on data supplied to the author by millers of the Region.

APPENDIX 12.4

VALUES FOR PULPWOOD CHIPS PRODUCED FROM HARDWOOD SAWMILLS.

Silver top ash was adopted as the basis for estimating values for pulpwood chips from hardwood sawmills because it is the principal species sawn in the Pulpwood Supply Zone. Some degree of error may therefore be inherent in values derived for chips produced from mills outside this Supply Zone because of the relatively small proportion of this species which is utilized. However the error involved is unlikely to be large because of its similarity in basic density or in the yield of kraft pulp of comparable Kappa number to many of the other species.

A green density of 1,156 kg/m^3 was adopted for silver top ash and was based on a basic density of 665 kg/m^3 and a moisture content for green wood of 73.8 percent (De Vries, pers. commun). The F.O.B. value of woodchips exports from Edrom was assumed to be equal to that used to derive pulpwood stumpages earlier in this Chapter i.e. $15.04 per green tonne of chips. By allowing five percent for defect and storage and handling losses at the chip mill, and after deducting an estimated $2.15 per green tonne for wharfage, chip handling and profit margin, the value of the chips delivered to the chip pile from the sawmill was estimated to be $12.14 per green tonne.

The following chip haulage costs were used as the basis for determining the value of the chips in the bin at the sawmill

50 kilometres from Edrom	-	$2.1 per tonne
100 kilometres from Edrom	-	$3.7 per tonne
220 kilometres from Edrom	-	$8.0 per tonne

These were based on Ironside and Krilov's (1973) cost estimates for an 18 tonne bulk carrier of maximum size and loading permitted on New South Wales roads and include loading and unloading costs.

The residual value of the chips in terms of solid wood (slabs, edgings, etc.) were calculated by deducting the cost of chipping based on a chipper of 55 tonnes per day capacity costing $50,000 (including the hopper or chip bin) in 1972/73 money values. Total costs based on the two hypothetical sawmills in this study are shown in Table 12.4.1:-

TABLE 12.4.1

Item		Sawmill A	Sawmill B
1.	Sawn output (m^3/annum)	5,360	16,521
2.	Chip output (tonnes/annum)*	3,718	11,458
3.	Costs:-		
	(i) Depreciation (straight line 10% salvage 10%)	4,500	4,500
	(ii) Labour at $0.50/tonne (includes 20% labour overheads)	1,859	5,729
	(iii) Power @ $0.55/tonne	2,045	6,302
	(iv) Maintenance and Repairs (50% of Depreciation for Sawmill A and 100% of Depreciation od Sawmill B)	2,250	4,500
	(v) Profit Allowance (15% on average profit bearing capital of $29 750)	4,463	4,463
	TOAL	$15,117	$25,494
4.	Cost per tonne	$4.07	$2.22

* This was equal to .60 x 1.156 of sawn output in 1.

To convert to chip values per gross tonne of solid wood, the net value was adjusted down by 5 percent to allow for fines and over-sized chips. The values so derived were then converted to values per cubic metre of sawn output by means of the following formula:-

Value of chips per cubic metre Sawn =
1.156 x 0.60 x Gross Value of Chips per tonne;

Where 1.156 is green density of the sawlog in kilogram per cubic metre solid volume;

and 0.60 is the factor expressing gross volume of chips recovered per cubic metre of sawn output.

APPENDIX 12.5

ESTIMATED COSTS OF EXTRACTION FOR SAWLOGS HARVESTED FROM DIFFERENT TYPES OF EUCALYPT FORESTS UNDER DIFFERENT CLASSES OF LOGGING CONDITIONS IN THE LOWER SOUTH COAST REGION.

Description	Snigging Output/day (m^3)	Felling Cost ($\$/m^3$)	Snigging Cost ($\$/m^3$)	Total Extraction Cost ($\$/m^3$)
A. Non-Integrated Logging				
1. High quality forests				
(a) Extensively roaded, steep	33	.85	3.1	3.95
(b) Extensively roaded, other	39	.85	2.6	3.45
(c) Intensively roaded, steep	45	.85	2.3	3.15
(d) Intensively roaded, other	52	.85	2.2	3.05

Description	Snigging Output/day (m^3)	Felling Cost ($\$/m^3$)	Snigging Cost ($\$/m^3$)	Total Extraction Cost ($\$/m^3$)
2. Other eucalypt forest types				
(a) Extensively roaded, steep	27	.90	3.8	4.70
(b) Extensively roaded, other	35	.90	2.9	3.80
(c) Intensively roaded, steep	38	.90	2.7	3.60
(d) Intensively roaded, other	43	.90	2.4	3.30
B. Integrated Pulpwood/Sawlog Logging (Exluding Debarking Cost)				
1. Tableland Management Areas				
(a) Areas converted to plantations	55	.80	1.9	2.7
(b) Other	50	.80	2.1	3.0

Description	Snigging Output/day (m^3)	Felling Cost ($\$/m^3$)	Sniggine Cost ($\$/m^3$)	Total Extraction Cost ($\$/m^3$)
2. Coastal Mountainous Areas				
(a) High quality types	45	.80	2.3	3.1
(b) Other types	36	.80	2.9	3.7
3. Coastal Hills				
(a) High quality types	50	.80	2.0	2.8
(b) Other types	42	.80	2.4	3.2
C. Integrated Pulpwood/Sawlog Logging (Including Debarking) Add \$0.40/cubic metre to costs derived under B.				

APPENDIX 12.6

SAWLOG STUMPAGE PRICES FOR EUCALYPT FORESTS

Supply Zone	Tenure	Management Area	Stumpage Price in $\$/m^3$ gross	
			Prior to 1995/96	1995/96+
Pulpwood	Crown	Bondi	6.72	7.45
		Coolangunbra	7.28	7.73
		East Boyd	7.72	10.84
		Glenbog	5.65	8.45
		Naghi	7.29	10.09
		Nullica-Bimmil	8.55	11.03
		Tantawanglo	6.07	7.61
		Towamba	6.37	8.97
		Yambulla North	6.84	9.64
		Yambulla South	6.79	9.59
		Yarammie-Burragate	7.49	10.29
		White Rock	6.80	9.37
	Private Property	Bega	8.04	9.05
		Bemboka	6.92	8.65
		Bondi	6.72	7.45
		Burragate	7.11	9.91
		Candelo	7.48	10.09

Supply Zone	Tenure	Management Area	Stumpage Price in $\$/m^3$ gross	
			Prior to 1995/96	1995/96+
		Lower Towamba	7.76	10.56
		Nungatta	5.85	8.81
		Pambula	8.04	10.84
		Wallagoot	7.40	10.09
		Wyndham	7.05	9.69
Transition	Crown	Brown Mt.	6.84	8.81
		Mumbulla	7.86	10.20
		Murrah	7.88	9.17
	Private Property	Cobargo	7.84	10.65
		Lower Brogo	7.64	10.15
		Mumbulla	7.86	10.20
		Murrah	7.88	9.17
Mining Timber	Crown	Belimbla	5.21	7.53
		Bodalla	6.46	8.54
		Currowan	5.90	8.28
		Mogo	6.72	9.10
		Moruya	5.89	8.47
		Nerrigundah	5.70	8.13
		North Kioloa	7.10	9.28
		Quartpot	5.71	8.09
		South Kioloa	7.06	9.45
		Tinpot	5.74	8.67
		Wadbillaga	5.36	7.99

Supply Zone	Tenure	Management Area	Stumpage Price in $\$/m^3$ gross	
			Period to 1995/96	1995/96+
	Private Property	Bodalla	6.46	8.54
		Currowan	5.90	8.28
		Mogo	6.72	9.10
		Moruya	5.89	8.47
		North Kioloa	7.10	9.28
		Quartpot	5.71	8.09
		South Kioloa	7.06	9.45
		Tinpot	5.74	8.67
Sawlog	Crown and Private Property	Araluen	4.38	5.93
		Badga	4.30	7.42
		Belowra	4.17	6.69
		Buckenbowra	5.95	8.49
		Burra Creek	4.54	7.05
		Deau	3.85	6.61
		Murrabrina	5.71	8.52
		Upper Tuross	4.22	7.02
		Yadboro	5.63	7.95
		Yourie	5.21	8.02

REFERENCES

Alexander, J.A. (1954) - Management of white stringybark forests for pulpwood production. Aust. For. 18(2): 74-85.

Auchter, R.J. (1973) - Raw material supply. Proc. Conf. on Future Technological Needs of the United States Pulp and Paper Industries, State Univ. of New York College of Environmental Science and Forestry, Syracuse, N.Y., p44-48.

Australian Bureau of Statistics (1974a) - Imports cleared for home consumption 1972-73. A.G.P.S., Canb.

Australian Bureau of Statistics (1974b and c) - Quarterly Summary of Statistics No. 288 and 289. A.G.P.S., Canb.

Australian Bureau of Statistics (1974d) - Overseas Trade 1972-73 Bulletin No. 70. A.G.P.S., Canb.

Australian Bureau of Statistics (1974e) - Money and Banking 1972-73. A.G.P.S., Canb.

Australian Bureau of Statistics (1975a) - Imports cleared for home consumption 1973-74. A.G.P.S., Canb.

Australian Bureau of Statistics (1975b) - Manufacturing Establishments, Details of Operations by Industry Class, Australia, 1972-73. A.G.P.S., Canb.

Australian Paper Manufacturers Ltd. (1974) - Submission to Land Conservation Council on the Melbourne Study Area. The Author, Melb., 88 pp (typed).

Baur, G.N. (Ed) (1965) - Forest types in New South Wales, Forestry Commission of N.S.W. Research Note No. 17, Syd., 80 pp.

Bentley, W.R. and D.E. Teeguarden (1965) - Financial maturity, a theoretical review. For. Sci. 11(1): 76-87.

Bergman, O. (1972) - Deterioration and protection of wood chips in outside storage. Report on FAO/NORAD Symp. on Protection, Handling and Transport of Wood Chips. FAO, Rome, p267-287.

Boer, D. de (1970) - Chemical release of Pinus radiata in grasslands. Appita 23: 291-298.

Bonner and Moore Associates Inc. (1975) - Sperry Rand 1100 Series Functional Mathematical programming system (FMPS), (folio).

Borough, C.J. and Reilly J.J. (1976) - Integrated farming and forestry. Paper pres. to National Conf. on "Limits to Growth and Options for Action", Aust. Inst. Ag. Sci., Canb. 3 pp (mimeo).

Brown, A.G. (1971) - Soil preparation for plantation establishment in Australia. Paper to 15th I.U.F.R.O. Congress, Gainesville, Fla, U.S.A., 11 pp.

Brown, H.A. and D. Hogg (1973) - The New South Wales South Coast Rural Economy. Canberra College of Advanced Education, Canb., 107 pp.

Brown, M.W. (1970) - Pruning methods and equipment (at Kaingaroa Forest). F.R.I. Symp. No. 12, N.Z. For. Serv., Well., p31.

Buick, R.G. (1969) - Mechanical stress grading of radiata pine. B. Sc. (For.) Hons. Thesis, Dept. of Forestry, Aust. Nat. Univ., Canb., 91 pp.

Buonjiorno, J. and D.E. Teeguarden (1973) - An economic model for selecting Douglas-fir reforestation projects. Hilgardia 42(3): 35-120.

Bureau of Agricultural Economics (1972) - Economic principles for increased beef production from butterfat dairy farms. Beef Research Report No. 9, The Author, Canb., 44 pp.

Bureau of Agricultural Economics (1973) - Statistical Handbook of the meat industry. A.G.P.S. Canb., 112 pp.

Bureau of Agricultural Economics (1974) - Dairy products situation and outlook. A.G.P.S., Canb., 80 pp.

Bureau of Agricultural Economics (1975a) - Protection to dairy farming in Australia. Industry Economics Monograph No. 8, A.G.P.S., Canb., 71 pp.

Bureau of Agricultural Economics (1975b) - The Australian beef cattle industry : Submissions to the Industries Assistance Commission Inquiry. Industry Economics Monograph No. 13, A.G.P.S., Canb., 105 pp.

Bureau of Agricultural Economics (1975c) - MEAT situation and outlook. A.G.P.S. Canb., 127 pp.

Bureau of Agricultural Economics (1977) - The Australian softwood products industry : plantation requirements to 1980 based on analysis of the supply and demand for forest products to 2020. A.G.P.S.,Canb., 182 pp.

Byles, B.U. (1958) - The responsibility of the forestry profession towards the management of forested lands for the purpose of protection. Aust. For. XXII (2): 55-58.

Candler, W. and M. Boehlje (1971) - Use of linear programming in capital budgeting with multiple goals. Am. J. Agric. Econ., 53(2): 324-330.

Carron, L.T. (1968) - An Outline of Forest Mensuration: with Special Reference to Australia. Aust. Nat. Univ. Press, Canb., 224 pp.

Cassidy, P.A. and R.C. Gates (1978) - Simulation, uncertainty and public investment analysis. Monograph No. 1, Business Research Centre, North Brisbane College of Advanced Education, Brisbane, 154 pp.

Cassidy, P.A. and J.C. Kilminster (1975) - Multiple objectives, public policy, and the economist. Econ. Anal. Policy, 6(1): 15-28.

Chapman, H.H. and W.M. Meyer (1947) - Forest Valuation. McGraw-Hill, N.Y., 521 pp.

Clutter, J.L., J.H. Bamping, J.E. Bethune, J.C. Fortson, L.A. Hargreaves, S.B. Kinne III, E.L. Norman, L.S. Shackelford and G.O. Ware (1968) - MAXMILLION a computerized forest management planning system. Biometrics - Operations Research Section, School of Forest Resources, Univ. of Georgia, Athens, 61 pp.

Committee of Inquiry into the National Estate (1974) - Report of the National Estate. A.G.P.S., Canb., 415 pp.

Commonwealth Bureau of Census and Statistics (1969) - Imports cleared for home consumption, 1967-68. The Author, Canb.

Commonwealth Bureau of Census and Statistics (1970) - Imports cleared for home consumption, 1968-69. The Author, Canb.

Commonwealth Bureau of Census and Statistics (1971) - Imports cleared for home consumption, 1969-70. The Author, Canb.

Commonwealth Bureau of Census and Statistics (1972) - Imports cleared for home consumption, 1970-71. The Author, Canb.

Commonwealth Bureau of Census and Statistics (1973a) - Imports cleared for home consumption, 1971-72. The Author, Canb.

Commonwealth Bureau of Census and Statistics (1973b) - Labour report No. 57, 1972. The Author, Canb.

Commonwealth Bureau of Census and Statistics (1973c) - Quarterly summary of Australian statistics No. 286. The Author, Canb.

Commonwealth Bureau of Census and Statistics (1973d) - Quarterly summary of Australian statistics No. 287. The Author, Canb.

Commonwealth Dairy Produce Equalisation Committee Ltd. (1973) - Thirty-ninth annual report of directors and balance sheet as at 30 June 1973. The Author, Canb., 15 pp.

Commonwealth Dairy Produce Equalisation Committee Ltd. (1974) - Fortieth annual report of directors and balance sheet as at 30 June 1974. The Author, Canb., 16 pp.

Cosco, J.N. (1971) - Growth and yield functions for P. radiata plantations in New South Wales. Symp. on Decision-Making, Dept. of Forestry, Aust. Nat. Univ., Canb., 5 pp (mimeo).

Cotton, M. (1975) - Comment paper on high-temperature drying radiata pine. Aust. For. Ind. J. 41(7): 57.

Cromer, R.N. and N.W. Hansen (1972) - Growth, nutrient uptake and pulping characteristics of young Eucalyptus globulus. Appita 26(3): 187-190.

Crook, D. (1967) - Chipping vs. slashing : a study of two methods of processing longwood. Tech. Pap., Amer. Pulp. Assoc., (Oct.), p23-26.

Croon, I. and E. Frisk (1972) - Outside chip storage (OCS). Report on FAO/NORAD Symp. on Production, Handling and Transport of Wood Chips, FAO, Rome p253-266.

Crowe, P.M. (1967) - Management Plan Kioloa Management Group Batemans Bay Sub District. Forestry Commission of N.S.W., Syd., 19 pp.

Curtin, R.A. (1969) - A provisional yield table for even-aged stands of blackbutt. Forestry Commission of N.S.W. Tech. Pap. No. 15, Syd., 9 pp.

Curtin, R.A. (1970a) - Increasing the productivity of eucalypt forests in N.S.W. Aust. For. 34(2): 97-106.

Curtin, R.A. (1970b) - Small timber production - dynamics of growth. Unpub. Internal Report of Forestry Commission of N.S.W., Syd., 15 pp.

Curtin, R.A. (1970c) - Analysis of growth in a mixed eucalypt forest. Forestry Commission of N.S.W. Res. Note No. 24, Syd., 31 pp.

Daly, R.A. and Co. (1969) - Which country has the lowest costs? Pulp and Paper (April), p8.

Dargavel, J.B. and I.S. Ferguson (1975) - Forest use conflicts in Victoria. Aust. For. 37(3): 215-224.

Dasgupta, P., A. Sen and S. Marglin (1972) - Guidelines for Project Evaluation. UNIDO Project Formulation and Evaluation Series No. 2, United Nations, N.Y., 383 pp.

Davies, L.H. (1972) - Beef production from temperate pastures. Aust. Meat Research Committee Review 5 : 1-12.

Davies, N., A.J. Watt and G.J. Deacon (1974) - A financial analysis of the Eden hardwood project. Forestry Commission of N.S.W. Tech. Paper No. 22, Syd., 22 pp.

De Vries, J. (1973) - The cost implications of owning and operating forest machinery in Australia. Leaflet No. 108 (2nd. Ed.), A.G.P.S., Canb., 43 pp.

Department of Labour and Industry, New South Wales (1973) - Dairy Employees (State) Award, N.S.W., New South Wales Ind. Gaz., 188 : 674-679.

Diedrich, E. (1967) - Costs in the pulp industry. Svensk Travaru-och Pappersmarstidning 10 : 509-515.

Dillner, B. (1972) - Outside stored chips as raw material for pulping. Report on FAO/NORAD Symp. on Production, Handling and Transport of Wood Chips, FAO, Rome, p288-301.

Dobie, J. (1967) - Chipper headrig productivity cuts small log milling costs. For. Ind., 94(9) : 82-85.

Dobie, J. (1974) - Small-log sawing methods more efficient. For. Ind., 101(4) : 36-38.

Dominion Bureau of Statistics, Canada (1968) - Trade of Canada Exports by Commodities. Nov. 1967. Information Canada, Ottawa.

Dominion Bureau of Statistics,Canada (1969) - Trade of Canada Exports by Commodities. Nov. 1968. Information Canada, Ottawa.

Dominion Bureau of Statistics, Canada (1970) - Trade of Canada Exports by Commodities. Nov. 1969. Information Canada, Ottawa.

Dominion Bureau of Statistics, Canada (1971) - Trade of Canada Exports by Commodities. Nov. 1970. Information Canada, Ottawa.

Dominion Bureau of Statistics, Canada (1972) - Trade of Canada Exports by Commodities. Nov. 1971. Information Canada, Ottawa.

Duerr, W.A. and H.J. Vaux (1953) - Research in the economics of forestry. Charles Lathrop Pack Forestry Foundation, Wash., D.C.

Duffy, P.J.P. (1969) - Forest land capability in the Queanbeyan-Shoalhaven area, A.C.T. and N.S.W. Aust. For. 33(3): 195-200.

Easter, C.D. and O.T. Kingma (1975) - A normative approach to the analysis of phosphate use : a farm-level study, p71-99 in Bureau of Agricultural Economics (1975) - Phosphatic fertilizers; submissions to the Industries Assistance Commission, A.G.P.S., Canb.

Edgar, J.C. (1974) - Land-use planning to achieve multiple objectives. Research Activity, Forests Commission, Vic., Melb., p33.

Eklund, R. (1972) - Integration of forest industries. Unasylva 21(2) : 17-26.

Fahey, T.D. and D.L. Hunt (1972) - Lumber recovery from Douglas-fir thinnings at a bandmill and two chipping canters. USDA Forest Serv., Res. Pap. PNW-131 Pacific Northwest Forest and Range Exp. Stat., Portland, Ore., 9 pp.

F.A.O. (1973) - Guide for Planning Pulp and Paper Enterprises. Forest and Forest Products Studies No. 18, United Nations, Rome, 379 pp.

Fenton, R. (1972) - Economics of radiata pine for sawlog production. N.Z. J. For. Sci.2(3) : 313-347.

Fenton, R. and J.R. Tustin (1972) - Profitability of radiata pine afforestation for the export log trade - on site index 95. N.Z. J. For. Sci. 2(1) : 7-68.

Ferguson, I.S. (1974) - Land use planning - analysis and action. Aust. For. 37(1) : 3-14.

Ferguson, I.S. (1974a) - Forecasting the future for timber. Aust. J. Agric. Econ. 17(3) : 159-169.

Ferguson, I.S. and P.J. Creig (1973) - What price recreation? Aust. For. 36(2) : 80-90.

Ferguson, I.S. and E.D. Parkes (1976) - International trade in forest products - 2 Development and prospects. Consultants' report for Dept. of Industry and Commerce, A.G.P.S., Canb., 52 pp.

Ferguson, I.S. and J.J. Reilly (1975) - The economics of modifying eucalypt forests. Aust. For. 38(2) : 134-143.

Ferguson, I.S. and J.J. Reilly (1975a) - The social discount rate and opportunity cost of capital, p85-93 in A.J. Grayson (Ed.), Evaluation of the contribution of forestry to economic development. Great Britain. For. Com. Bull. No. 56. Proc.

Ferguson, I.S. and J.J. Reilly (1977) - The economics of joint agriculture/forestry enterprises. Paper pres. to Workshop on Integrating Agriculture and Forestry, Bunbury, W.A. 7 pp.

Field, D.B. (1973) - Goal programming for forest management. For. Sci. 19(2): 125-135.

Florence, R.G. (1968) - The role of blackbutt in East Coast forests. Aust. For. 32(2): 118-127.

Florence, R.G. and K.R. Shepherd (1975) - The role of eucalypt forests in wood production. Aust. For. 38(2): 100-116.

Forestry and Timber Bureau (1975) - Australian forest resources 1974. A.G.P.S. Canb., 65 pp.

Forestry Commission of New South Wales (undated) - E and M Bulletin. Internal publication. The Author, Syd.

Forestry Commission of New South Wales (1974) - 1972-1973 Annual Report. Gov. Printer, N.S.W. Syd., 56 pp.

Forrest, W.G. (1969) - Variation in the accumulation, distribution and movement of mineral nutrients in radiata pine plantations. Unpublished Ph. D. Thesis, Dept. of For., Aust. Nat. Univ., Canb., 276 pp.

Forrest, W.G. (1974) - Profitability of thinnings in radiata pine plantations. N.Z. J. For. Sci. 4(3): 529-539.

FORWOOD (1974a) - Report of Panel 2, Forest Resources, A.G.P.S., Canb., 56 pp.

FORWOOD (1974b) - Report of Panel 4, Harvesting. A.G.P.S., Canb., 76 pp.

FORWOOD (1974c) - Report of Panel 6, Marketing. A.G.P.S. Canb., 109 pp.

Furrer, B.J. (1971) - Management and silviculture in the spotted gum forests in the South Coast of New South Wales. Unpublished M. Sc. Thesis, Dept. of For., Aust. Nat. Univ., Canb.

Gentle, S.W. (1971) - Fertilizer technology - Pinus radiata. Proc. of Pinus radiata Symp. Dept. of For., Aust. Nat. Univ., Canb., 25 pp.

Gibson, B.F. (1971) - Land-use planning with multiple objectives : a systems approach for non-urban land. Unpublished paper, the Author, 9 pp (mimeo).

Gollin Holdings Ltd. (1973) - Evidence presented to Parliamentary Committee on Prices (Sub-Committee A) (Reference : Currency Revaluation - Price Effects), Official Hansard Report, Gov. Printer of Aust., Canb., p292-293.

Goudie, M. (1971) - Logging pulpwood. Proc of Pinus radiata Symp., Dept. of For., Aust. Nat. Univ., Canb. P8C.1 to 8C.6.

Grayson, A.J. (1969) - Imports and consumption of wood products in the United Kingdom 1950-1967, with forecasts to 1980. For. Com. Forest Record No. 70, 42 pp.

Greig, P.J. (1974) - The management decision-making process in the multiple use of forested land with particular reference to recreational uses. Aust. Recreation Research Association Monograph No. 1, 99 pp.

Grosenbaugh, L.R. (1967) - REX - FORTRAN - 4 SYSTEM for combinatorial screening on conventional analysis of multivariate regressions. USDA For. Serv. Res. Pap. No. PSW-44, Pacific South West Forest and Range Exp. Stn., Berkeley, Cal., 47 pp.

Gruen, F.H. (1972) - The optimum size of Australian agriculture, 44th ANZAAS Congress, Syd., 18 pp (mimeo).

Gunn, R.H. (1969) - Soils of the Queanbeyan-Shoalhaven area. In lands of the Queanbeyan-Shoalhaven area, A.C.T. and N.S.W., Land Res. Series 24, C.S.I.R.O., Melb., p92-112.

Hall, M.J. (1956) - A study of site quality in Eucalyptus obliqua (L'Herit.). Unpub. M.Sc. For. thesis, Univ. Melb.

Hall, M.J. (1959) - The effect of stocking density, site quality and age on the volume of pulpwood produced per acre. Appita 13(1): 22-29.

Hall, M.J. (1974) - A plantation simulation model for radiata pine. Appita 27(4): 251-261.

Hall, M.J., N.W. Hansen and A.B. Rudra (1973) - The effect of species, age and wood characteristics on eucalypt kraft pulp quality. Appita 26( ) : 348-354.

Hamilton T.E. (1968) - Production, prices, employment, and trade in Pacific Northwest forest industries. USDA Forest Serv. Pacific Northwest Forest and Range Exp. Stat., Portland, Ore. 28 pp.

Harris, S.F. (1964) - Some measures of costs of protection in Australian rural industries. Aust. J. Agric. Econ. 8(2): 124-144.

Harris, S.F., Sir J.G. Crawford, F.H. Gruen and N.D. Honan (1974) - Rural policy in Australia. Report to the Prime Minister by a Working Group, May 1974. A.G.P.S., Canb., 323 pp.

Hayden, E.J. (1971) - The natural plant communities of New South Wales. Unpublished M. Sc. thesis, Aust. Nat. Univ., Canb.

Henderson, P.D. (1965) - Notes on public investment criteria in the United Kingdom, p86-169 in R. Turvey (Ed.), Public Enterprise : Selected Readings, Penguin, Harmondsworth.

Holmes, J.H. (1961) - The derivation and use of an index of dairy potential. Rev. Market. Agric. Econ. 29 : 184-205.

Holt, E. (1974) - Production, prices, employment and trade in Northwest forest industries, Fourth Quarter, 1973. USDA Forest Serv., Pacific Northwest Forest and Range Exp. Stat., Portland, Ore., 45 pp.

Hoschke, F.G. (1966) - Continuous forest inventory system Kendall Management Area. Tech. Pap. No. 20, Forestry Commission of N.S.W., Syd., 78 pp.

Hoschke, F.G. and R.V. Wilson (1974) - The FORINS information system for land use studies. Vol. I, Working Papers, Inst. of Foresters of Aust. Sixth Triennial Conference, Caloundra, p81-97.

Host, J.R. (1969) - Economics of producing and handling packaged timber. USDA Forest Serv. Res. Pap. INT - 66. Intermountain Forest and Range Exp. Stat., Ogden, Utah, 12 pp.

House of Representatives (1974) - Parliamentary Debates, 20 March 1974. Daily Hansard, 28th Parliament, A.G.P.S.,Canb.

House of Representatives Standing Committee on Environment and Conservation (1975) - Report on the operation of the Softwood Forestry Agreements 1967 and 1972. Parliamentary Paper No. 115, A.G.P.S. Canb., 59 pp.

Humphreys, N. (1970) - Value resulting from cultural techniques of thinning and pruning. Vol. I, Proc. Pinus radiata Symp., Dept. of Forestry, Aust. Nat. Univ., Canb., p3D.1 to 3D.20.

Hynd, D.J. (1962) - Bodalla Management Group Working Plan. Unpublished Internal Report, Forestry Commission of N.S.W., Syd.

Incoll, W.D. (1974) - A Tree and Stand Growth Model for Eucalyptus sieberi F. Muell. Unpublished M. Sc. For. thesis, Univ. Melb., 176 pp.

Industries Assistance Commission (1974) - Annual Report 1973-74. A.G.P.S., Canb., 196 pp.

Industries Assistance Commission (1975) - Dairy Industry Report. A.G.P.S., Canb., 232 pp.

Ironside, G.E. and A. Krilov (1973) - Transport facilities - key to woodchip export expansion. Aust. For. Ind. J. 39(10): 29-33.

Jacobs, M.R. (1955) - Growth Habits of the Eucalypts. Forestry and Timber Bureau, Canb., 262 pp.

Josephson, H.R. and D. Hair (1974) - The situation and trends for timber in the United States. Unasylva, 26(105): 2-9.

Kalish, J. (1973) - SSSF's Värö project ; bleached kraft pulp from Europe's most efficient mill. Pulp and Paper International, 15(1): 31-36.

Koch, P. (1973) - Whole-tree utilisation of southern pines advanced by developments of mechanical conversion. For. Prod. J., 23(10): 30-33.

Lal, D. (1974) - Methods of project analysis : a review. World Bank Staff Occasional Paper, No. 16, John Hopkins Univ. Press, Baltimore, 56 pp.

Layard, R. (1972) - Introduction p9-65 in R. Layard (Ed.), Cost-Benefit Analysis, Penguin, Harmondsworth.

Lembke, C.A. (1972) - Duncan's (Eden) outstanding hardwood sawmill. Aust. For. Ind. J. 38(8) : 12-36.

Lembke, C.A. (1974) - AFI's outstanding integrated Myrtleford complex. Aust. For. Ind. J. 40(9): 2-23.

Lembke, C.A. (1975) - Canadian dimension - A community product for the Australian market. Aust. For. Ind. J. 41(7): 23-32.

Lewis, N.B., A. Keeves, and J.W. Leech, (1976) - Yield Regulation in South Australian Pinus radiata Plantations. Bull. No. 23, Woods and Forest Dept., S. Aust., 174 pp.

Little, I.M.B. and J.A. Mirrlees (1968) - Manual of Industrial Project Analysis in Developing Countries. Vol. II, Social Cost-Benefit Analysis. Development Centre, O.E.C.D., Paris, 280 pp.

Lloyd, P.J. (1973) - Non-Tariff Distortions of Australian Trade. Aust. Nat. Univ. Press, Canb., 243 pp.

Lofts, K.G. (1960) - The geographical study and evaluation of the unoccupied lands in the Imlay Shire in terms of present land use and economy. Unpublished Masters thesis, Univ. Syd., 103 pp.

Longworth, L.D. (1958) - Soil erosion and its control on the Far South Coast. J. Soil Conserv. Serv. N.S.W., 14 : 131-136.

Maddern Harris, J. (1965) - A survey of the wood density, tracheid length and latewood characteristics of radiata pine grown in New Zealand. Tech. Pap. No. 47., N.Z. For. Serv. Well., 31 pp.

Mann, M.J. (1955) - Management and Silviculture in a mixed species demonstration and research forest. Unpublished M. Sc. For. thesis, Univ. of Melb.

Manning, G.H. (1971) - Linear programming, resource allocation and non-market benefits. Publication No. 1298, Dept. of the Environment., For. Serv., Information Canada, Ottawa, 18 pp.

Manning, G.H. and H.R. Grinnell (1971) - Forest resources and utilisation in Canada to the year 2000. Publication No. 1304, Dept. of Environment., For. Serv., Ottawa, 80 pp.

Mason, H.C. and Associates Inc. (1973) - Study of softwood sawlog conversion efficiency and the timber supply problem, USDA, For. Serv., Wash., 202 pp.

Mathews, R.L. (1971) - The Accounting Framework, 3rd Rev. ed., Cheshire, Melb., 585 pp.

McCarthy, W.O., P.L. Nuthall, C. Higham and D. Ferguson, (1970) - Economic evaluation of land use alternatives for the Southern Wallum Region, Qld. Tropical Grasslands 4(3): 195-212.

McCumstie, R.F. (1973) - The New South Wales beef cattle industry. Quart. Rev. Agric. Econ., XXVI(2): 117-139.

McEwan, T.K. (1974) - Analysis of the effect of the lumber recovery factor (LRF) on sawmill costs, For. Prod. J., 24(3): 17-19.

McKinnell, F.H. (1970) - Wood density studies in Pinus radiata. Unpublished Ph. D. thesis, Aust. Nat. Univ., Canb., 188 pp.

McKinnell, F.H. (1974) - Low pruning radiata pine, Aust. For. 37(1): 24-31.

Mead, W.J. (1966) - Competition and Oligopsony in the Douglas-Fir Lumber Industry. Univ. of California, Los Angeles, 276 pp.

Miles, J.A., I.S. Ferguson and J.J. Reilly (1976) - A linear programming matrix generator for forest planning models. Workshop on Recent Developments in Forest Models, Research Working Group 2, Mensuration and Management, Australian Forestry Council, Melb., 13 pp (mimeo).

Milk Authority of the Australian Capital Territory (1974) - Report of the inquiry into the milk industry in the Australian Capital Territory, A.G.P.S., Canb., 88 pp.

Ministry of Finance, Japan (1973) - Japan exports and imports commodity by country 1972 - Japan Tariff Association.

Ministry of Finance, Japan (1974) - Japan exports and imports commodity by country 1973. Japan Tariff Association.

Mishan, E.J. (1971) - Cost-Benefit Analysis - Allen and Unwin, London, 364 pp.

Navon, D.I. (1971) - Timber RAM - a long-range planning method for commercial timber lands under multiple-use management. USDA For. Serv. Res. Pap. PSW-70, Pacific South West Forest and Range Exp. Stn., Berkeley, Cal., 22 pp.

Nelson, P.J., A.J. Watson, R.B. Bain and V. Baladis (1973) - An assessment of the resin and a comparison of the pulping properties of Pinus pinaster and Pinus radiata. Appita 27(2): 99-106.

New Zealand Forest Service (1975) - Report of the Director-General of Forests for the year ended 31 March, 1974. Gov. Print., N.Z., Well.

Northcote, K.H. (1962) - Atlas of Australian Soils, Sheet 2, Melbourne-Tasmania Area, CSIRO Aust. and Melb. Univ. Press, Melb.

Opie, J.E. (1962) - STANDSIM - A general model for simulating growth of even-aged stands. Proc. of Third Conf. Advisory Group Forest Statisticians, Section 25, I.U.F.R.O., Jory-en-Josas, France.

Packham, G.H. ed. (1969) - The geology of N.S.W. J. Geol. Soc. Aust. 16: 1-654.

Papadopolous, C. (1973) - Factors determining Australian saleyard prices for beef cattle. Quart. Rev. Agric. Econ., XXVI(3): 159-170.

Parish, R.M. and J.L. Dillon (1955) - Recent applications of the production function in farm management research. Rev. Market.and Agric. Econ. 23: 215-236.

Porterfield, R.L. (1974) - Predicted and potential gains from tree improvement programs - a goal programming analysis of program efficiency. Tech. Rep. 52, N.C. State Univ., Raleigh, N.C., 112 pp.

President's Advisory Panel on Timber and the Environment (1973) - Report of the President's Advisory Panel on Timber and the Environment - U.S. Govt. Print. Office, Wash., D.C., 541 pp.

Prest, A.R. and R. Turvey (1965) - Cost-Benefit analysis : a survey. Econ. J., 75: 683-735.

Rance, G.A. and J.B. Gordon (undated) - Farm management strategies for winter feeding - N.S.W. Department of Agriculture, 15 pp (mimeo).

Reeves, G.W. and A.H. Hayman (1975) - Demand and supply forces in the world beef market. Quart. Rev. Agric. Econ. XXVIII(3): 121-151.

Reilly, J.J. (1971) - The utilisation of the southern pines. Part 1. Sawmilling. Internal Report, Dept. of For., Queensland.

Reilly, J.J., E.D. Parkes and I.S. Ferguson (1975) - The potential productivity of farmlands in the Lower South Coast Region of New South Wales for radiata pine plantations. Aust. For. 37(3): 233-244.

Ridley, P. (1972) - Contract rates for various farm operations in N.S.W., 1972. N.S.W. Dept. of Agric., Syd., 99 pp.

Rogers, T.E. (1970) - A problem in implementing a silvicultural schedule. F.R.I. Symp. No. 12, Vol. 2 : Papers, N.Z. For. Serv., Well., p233-236.

Routley, R. and V. Routley (1973) - The fight for the Forests. Research School of Social Sciences, Aust. Nat. Univ., Canb., 290 pp.

Ryan, J.G. (1975) - Using input demand and production function models to assess the net benefits of dairy herd improvement. Aust. J. Agric. Econ. 19(1): 23-38.

Ryan, K.B. (1965) - Towns and settlement of the South Coast, N.S.W. Unpublished Ph. D. thesis, Aust. Nat. Univ., Canb., 420 pp.

Shepherd, K.R. (1967) - Influence of low pruning on first thinnings in radiata pine plantations. Aust. For. 31(1): 45-49.

Standen, B.J. (1970) - Direct costs and returns from the installation and operation of refrigerated milk vats - the farmer's viewpoint. Misc. Bull. 10, N.S.W. Dept. of Agric., Syd., 22 pp.

Statistics Canada (1972) - Canadian statistical review. Historical summary, 1970. Ministry of Industry, Trade and Commerce, Information Canada, Ottawa.

Statistics Canada (1973a) - Canadian statistical review. December 1972. Ministry of Industry, Trade and Commerce, Information Canada, Ottawa.

Statistics Canada (1973b) - Trade of Canada Exports by commodities, November 1972. Information Canada, Ottawa.

Statistics Canada (1974a) - Canadian statistical review. December 1973. Ministry of Industry, Trade and Commerce, Information Canada, Ottawa.

Statistics Canada (1974b) - Trade of Canada Exports by commodities. November 1973. Information Canada, Ottawa.

Street, J.A. (1974) - Demand for milk. Rev. Market. Agric. Econ., 42(2): 100-113.

Stuckey, H.J. (1969) - Cost comparisons of chipping versus slashing in pulpwood production in Arkansas. Unpublished M. Sc. thesis, School of Forestry and Wildlife Management, Louisiana State Univ. and Agric. and Mech. College, Baton Rouge, La.

Tak, van der, H.G. and L. Squire (1975) - Economic Analysis of Projects. Bank Working Staff Paper No. 194, International Bank for Reconstruction and Development, John Hopkins, Balt., 156 pp.

Taylor, F.W. and M.W. Garton (1970) - The systematic evaluation of a pine sawmilling operation. Forest Products Utilisation Lab., Research Report No. 9, Mississippi State Univ. State College, 37 pp.

Terlesk, C.J. (1969) - A comparison of two methods of pruning, 8 to 14 ft. N.Z. J. For. 14(1) : 90-95.

Twitchell, J.P. and L.L. Edwards (1974) - Kraft mill material balance calculations for brown stock washing, screening, and oxygen bleaching. Tappi, 57(9) : 98-102.

U.S. Department of Commerce (1975) - U.S. exports Schedule B FT4101 December 1974, Bureau of the Census, Wash., D.C.

U.S. Department of Commerce (1969) - 17th Biennial Edition A Supplement to the Survey of Current Business Statistics. Superintendent of Documents, U.S. Gov. Print. Office, Wash., D.C.

U.S. Department of Commerce (1970, 1971, 1972, 1973 and 1974) - Survey of Current business, Superintendent of Documents, U.S. Gov. Print. Office, Wash., D.C. (monthly).

Vanho, J. and K. Henricsson (1975) - The pulpmill of tomorrow. Pulp and Paper International 17(2) : 33-35, 51.

Walker, P.H. (1960) - A reconnaissance of the soils and land use of part of the South Coast of N.S.W.

Walpole, C.L.A. (1975) - Severe pulp shortage plus higher paper prices predicted by 1980. Pulp and Paper International 17(2) : 36-39.

Water Conservation and Irrigation Commission (1966) - N.S.W. Survey of Thirty-Two N.S.W. River Valleys. Report No. 1., The Author, Syd., 112 pp.

Water Conservation and Irrigation Commission (1968) - Survey of Thirty-Two N.S.W. River Valleys. Report No. 10. The Author, Syd., 107 pp.

Water Conservation and Irrigation Commission (1970a) - Survey of Thirty-Two N.S.W. River Valleys. Report No. 18. The Author, Syd., 98 pp.

Water Conservation and Irrigation Commission (1970b) - Survey of Thirty-Two N.S.W. River Valleys. Report No. 20. The Author, Syd., 117 pp.

Water Conservation and Irrigation Commission (1970c) - Survey of Thirty-Two N.S.W. River Valleys. Report No. 21. The Author, Syd., 109 pp.

Watson, A.J., H.G. Higgins and L.A. Bryant (1974) - Extension of pulpwood resources in southern N.S.W forests - utilisation of E. cypellocarpa and E. sieberi. Appita 28(3): 175-180.

Watt, A.J. (1971) - Optimal two phase sampling patterns for extensive tracts of low valued forested land. Paper pres. to Symp. on General Survey of Timber Reserves and Anticipated Demands for Forest Products within the Pacific Region, Twelfth Pacific Sci. Cong., Canb., 10 pp (mimeo).

Watt, A.J. and J.J. Douglas (1974) - Royalty systems : principles and policies. 23rd AUSTIS Conf., Wodonga, Vic., 15 pp (mimeo).

Weir, I.C.A. (1972) - Planning of wood production using systems analysis. Appita 26(2): 107-112.

West Coast Lumber Inspection Bureau (1970) - Standard grading rules for West Coast lumber No. 16. The Author, Portland, Ore., 213 pp.

Williams, D.L. and W.C. Hopkins (1968) - Converting factors for southern pine products. Bull. No. 626, Louisiana State Univ. in coop. with Southern Forest Exp. Stat., USDA For. Serv., New Orleans, 89 pp.

Working Party on Douglas Fir (1972) - Report on Douglas fir. Joint Consultative Council on Forest Industries, N.A.F.T.A. Department of Trade and Industry, Canb., 27 pp.